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NUCLEAR REGULATORY COMMISSION

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590TH MEETING

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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THURSDAY

JANUARY 19, 2012

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ROCKVILLE, MARYLAND

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The Advisory Committee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B3, 11545 Rockville Pike, at 8:30 a.m., J. Sam Armijo, Chairman, presiding.

COMMITTEE MEMBERS:

J. SAM ARMIJO, Chairman

JOHN W. STETKAR, Vice Chairman

HAROLD B. RAY, Member-at-Large

SAID ABDEL-KHALIK, Member

SANJOY BANERJEE, Member

DENNIS C. BLEY, Member

CHARLES H. BROWN, JR. Member

MICHAEL L. CORRADINI, Member

COMMITTEE MEMBERS (CONT.)

DANA A. POWERS, Member
JOY REMPE, Member
MICHAEL T. RYAN, Member
STEPHEN P. SCHULTZ, Member
WILLIAM J. SHACK, Member
JOHN D. SIEBER, Member
GORDON R. SKILLMAN, Member

NRC STAFF PRESENT:

WEIDONG WANG, Designated Federal Official
CHAKRAPANI BASAVARAJU, NRR/DE/EMCB
GORDON CLEFTON, NRR
PAUL CLIFFORD, NRR/DSS
MICHELLE FLANAGAN, RES
ALLEN G. HOWE, NRR
TARA INVERSO, NRR
RALPH LANDRY, NRO
SAMUEL MIRANDA, NRR
MARTIN MURPHY, NRR/DE/EMCB
JASON C. PAIGE, NRR
BENJAMIN PARKS, NRR
WILLIAM RULAND, NRR
ANTHONY ULSES, NRR/DSS
LEONARD WARD, NRR

ALSO PRESENT:

LIZ ABBOTT, FPL
CESARE FREPOLI, Westinghouse
STEVE HALE, FPL
MIKE KILEY, FPL
ED MONAHAN, Westinghouse
CARL O'FARRILL, FPL
SAM SHAFER, FPL

TABLE OF CONTENTS

P-R-O-C-E-E-D-I-N-G-S

8:30 A.M.

CHAIR ARMIJO: Good morning. The meeting will now come to order. This is the first day of the 590th meeting of the Advisory Committee on Reactor Safeguards. During today's meeting, the Committee will consider the following: Turkey Point Units 3 and 4 Extended Power Update Application; Proposed Revision to 10 CFR 50.46, "Acceptance Criteria for Emergency Core Cooling Systems for Light-Water Nuclear Power Reactors"; Future ACRS Activities and a Report of the Planning and Procedures Subcommittee; Reconciliation of ACRS Comments and Recommendations; Draft Report on the Biennial ACRS Review of the NRC Safety Research Program; and Preparation of ACRS Reports.

The meeting is being conducted in accordance with the provisions of the Federal Advisory Committee Act. Mr. Weidong Wang is the Designated Federal Official for the initial portion of the meeting.

We have received no written comments or requests for time to make oral statements for members of the public regarding today's sessions.

There will be a phone bridge line. To preclude interruption of the meeting, the phone will be placed on a listening mode during the presentations and Committee discussion.

A transcript of portions of the meeting is being kept and it is requested that the speakers use one of the microphones, identify themselves, and speak with sufficient clarity and volume so that they can be readily heard.

I will begin with an item of current interest. Dr. Stephen Schultz is now an official member of the ACRS and we would like to welcome him on board. Steve.

(Applause.)

Dr. Schultz has completed over 33 years of service in the U.S. nuclear industry. He most recently managed the Duke Energy Nuclear Design Team providing nuclear core design and related engineering services for seven PWRs. From 1977 to 1997, Dr. Schultz served the Yankee Atomic Electric Company in a variety of positions culminating in Vice President for Engineering Services.

Dr. Schultz applies over 30 years of nuclear executive and line management experience in technical, regulatory, and resource management through his employment with both Duke Energy and Yankee Atomic Electric Corporation. He has just completed an assignment with the IAEA in Vienna working on programs for reactor development and assessment.

Dr. Schultz has authored and co-authored over 20 publications in relevant nuclear engineering and other scientific journals. Dr. Schultz holds an M.S. in Nuclear Science and Engineering from Rensselaer Polytechnic Institute and a doctorate in Nuclear Engineering from the Massachusetts Institute of Technology. He is a registered professional engineer in North Carolina. Again, welcome.

Okay, the first item on the agenda is the Turkey Point Units 3 and 4 extended power uprate and Dr. Bill Shack will lead us through that.

MEMBER SHACK: We had a Subcommittee meeting in December on this uprate. It's a 15 percent increase in license core power that they're looking at. That's a 13 percent power uprate and a 1.7 measurement uncertainty recapture. The license amendment was prepared utilizing the review standard for extended power uprates and addresses the issues and provides the analyses generally identified in the review standard.

I would point out they've made numerous hardware modifications. They've installed the leading edge flow measurement system which is for their measure uncertainty recapture, refurbished auxiliary feedwater pumps, removed auxiliary feedwater control valve travel stops. They have a new high-pressure turbine, new turbine controls, new moisture separate reheaters, and replaced the main condenser. They've also done code changes to support the uprate. Several code changes were made. Probably the most important one is the switch to the ASTRUM large-break LOCA methodology to give them some more margin there. But all the codes that they're using have received prior NRC approval. The applicant discussed issues like steam generator tube vibration and boric acid precipitation analysis that have arisen in other EPU reviews.

We did have a number of open issues that came from the Subcommittee. Probably the most important and one we haven't seen before was the effect on fuel thermal conductivity decrease with burnup which was identified in Information Notice 2009-23. Subcommittee members also noted there was a rather small margin to RCS pressure limits in the non-LOCA overheating analysis. Staff had proposed a spent fuel pool license condition concerning the mods that are needed for operation at EPU and we had some problems with the wording of that license condition.

There were also questions about the reference documents that were used to determine the acceptability of the zone of influence for GSI-191 and other impact analyses, although the EPU itself is being treated independently of the GSI-191 resolution.

We'll hear about the status of these open issues today. However, additional issues have been identified by the staff since the Subcommittee meeting that they will tell us about. Because we're still looking at the resolution of these issues, we will not be writing a letter on the EPU at this meeting. That will probably occur in the March meeting. These issues obviously have to be resolved and the resolution has to be available for our review before we can proceed with the letter and we're just not there at the moment.

With that, I'll turn the presentation over to the NRC staff.

MR. HOWE: Thank you, and good morning. I'm Allen Howe, Deputy Director, Division of Operating Reactor Licensing in the Office of Nuclear Reactor Regulation.

We do appreciate the opportunity to brief the ACRS today on the Turkey Point extended power uprate application. We briefed the Subcommittee, as you mentioned, back in December on this topic. We are going to provide an overview of the application. The licensee will provide information on their modifications and their analysis for the application. The NRC staff will discuss our review and our findings.

As was mentioned, there are some open items. The staff will discuss the resolution of those open items or the status of the resolution of those open items as some of them are continuing to be worked at this point in time.

We've worked diligently to address those issues, however, as you'll hear during the presentation we have encountered some unique challenges as a part of this and we will need to come back and rebrief the ACRS.

That being said, I am very pleased with the thoroughness and the comprehensiveness of the staff's review including the efforts to address the thermal conductivity degradation and the other emerging issues that you'll hear a little bit more about. We've had frequent interactions with the licensee during this period of time and during the review. We've had multiple rounds of requests for additional information. We've done audits of licensee and vendor analyses as a part of that. We think that this interaction, this dialogue really helped us out with our understanding and moving the staff's review forward.

I'd like to, at this point, turn the discussion over to Jason Paige who is the project manager for this review. Thank you.

MR. PAIGE: Thank you, Allen. Good morning. My name is Jason Paige. I'm the project manager in the Office of NRR assigned to Turkey Point. First, I'd like to take this opportunity to thank the ACRS members for your effort in reviewing the proposed EPU application and providing this opportunity for the staff to present the results of its review to you.

I also want to express my thanks to the NRR technical review staff for conducting a thorough review of a very complex application and also for providing support to these meetings. During today's full Committee meeting, you will hear from both the licensee and the NRC staff on the details of the EPU application.

Our objective is to provide an overview of the Turkey Point EPU application, present the results of the staff's review, and provide a status of open items generated during and after the ACRS Subcommittee meeting in December 2011.

Before I cover agenda items for today's meeting, I would like to provide some background information related to the proposed EPU. On October 21, 2010, the licensee submitted its license amendment request for the Turkey Point Units 3 and 4 EPU. The amendment would increase each unit's licensed thermal power from 2,300 megawatt thermal to 2,644 megawatt thermal. This represents a net increase of 15 percent including a 13 percent extended power uprate and a 1.7 percent measurement uncertainty recapture. This would also represent a 20 percent increase from the original licensed thermal power level.

The staff's method of review was based on Review Standard-001 which is NRC's review standard for extended power uprates. This review standard provides guidance to the NRC staff for their review of EPU applications including acceptance criteria, a safety evaluation template, and matrices that identify the multiple technical areas the staff is to review.

There are no open licensing actions associated with or linked to this EPU application. The staff recently issued two associated amendments the licensee needed before it could implement the EPU. The staff approved an alternative source term amendment and a spent fuel pool criticality analysis amendment in June and October 2011, respectively.

The licensee submitted approximately 45 supplements to the application in response to the multiple staff requests for additional information which supported the staff's completion of its safety evaluation. In addition, the staff conducted several audits to complete its review and resolve open items.

This slide provides the agenda topics that will be covered during today's presentations. The presentations will include five open items generated from the Subcommittee meeting on December 14th and additional issues that were recently identified by the staff. The staff will provide details and the status of these open items during their presentations.

The licensee will provide an overview of the proposed EPU and related proposed plant modifications. The NRC staff will then provide an overview of its review and safety analysis, focus presentations on the thermal conductivity degradation issues, and the two mechanical and civil engineering open items generated during the Subcommittee meeting.

During the Subcommittee meeting, the staff presented an emerging issue regarding the thermal conductivity degradation as an open item. At the conclusion of the meeting, the Subcommittee requested that the staff forward any licensee supplements related to this issue to the ACRS and address the resolution of staff findings on the issue during today's meeting. The licensee supplements dated December 31, 2011 and January 16, 2012 were provided to the ACRS and will be discussed by the licensee during its presentation.

Although the staff and the licensee have worked diligently to resolve this issue before today's meeting, you will hear during our presentations that this issue has presented unique challenges and remain as an open item. The licensee and staff will provide a status and additional details on this issue in our proposal to disposition the issue during a subsequent ACRS meeting.

Unless there are any questions, I'd like to turn the presentation over now to Mr. Mike Kiley for the licensee's presentation.

MEMBER SHACK: Let me ask a question. The mechanical degradation, we've seen a number of large EPUs for PWRs, Point Beach, Kewaunee. Why is this issue being raised now and is it something that has to go back and looked at in some of these other EPUs?

MR. HOWE: Tony, could you address that

issue, please?

MR. ULSES: This is Tony Ulses. I'm the Branch Chief of the Reactor Branch. The short answer is yes, it needs to be dealt with and it has been dealt with by licensees. In response to the Information Notice, they all did an immediate determination of operability and all concluded that they had adequate margin in their analysis right now to accommodate this. However, we are continuing to address this issue generically and we are continuing to follow it.

MEMBER SHACK: Was it addressed in the EPUs, the large EPUs that we've looked at for the PWRs?

MR. ULSES: Our first understanding of the magnitude of this issue was identified to us in early December of last year. So the short answer is we knew about the issue, but we've never seen a quantification of the magnitude of the issue until last year in December. And so we acted very quickly and we got the Information Notice out of the NRC within a matter of a week in order to get the information out to licensees for them to have the information to take the appropriate actions as required by the rule.

MR. PAIGE: Unless there's any other

questions, I'll turn it over to Mr. Mike Kiley. He's the Site Vice President at Turkey Point.

MEMBER BANERJEE: Bill, what did you imply by your question? I'm trying to understand.

MEMBER SHACK: Oh, just the question of whether this has to be reexamined for some of those other large EPUs that we've looked at for PWRs. We're here today -- you have to take some steps in your core design to address it and the question is have the other EPUs considered that and will it impact their core design?

MEMBER BANERJEE: I think then the answer is not all that clear because Tony, does that mean that the other EPUs such as Point Beach and so on are just addressing the issue independent of the EPU? What's going on?

MR. ULSES: Let me try to speak a little more about this in the context of what's required by the rule. 50.46 has a process in it that allows for the identification of errors or changes to the evaluation models. In other words, it's expected that if an error is out there, we will find errors in the methodology. That rule requires that the licensee make an assessment of the impact of the error. They have to identify whether or not that error will cause any of the 50.46 acceptance criteria to not be met. In other words, in this case, the 2200 value on PCT is really the driver here. All the licensees have taken the information that was provided in the information notice and they have done that assessment. And they have concluded that they have adequate margin in either their ECCS evaluation model or how they operate their plant.

In other words, the analysis is generally done in extremely limiting conditions and the plant doesn't operate at those conditions. And therefore, they've concluded that they have adequate margin. But as I said, we are continuing to follow this issue generically and we will also follow it on a price-specific basis as needed and as the information comes to us.

CHAIR ARMIJO: I'd just like to ask a question. Is that adequate margin based on the ECCS analysis of record is margin because there's been some modifications or conservatisms available to be put into the analysis of record?

MR. ULSES: I think what you're asking is is there margin to -- in how the plant is operated versus how it was analyzed -- is that the question?

CHAIR ARMIJO: No. The analysis that's

used to establish PCT --

MR. ULSES: Right.

CHAIR ARMIJO: Even with the thermal conductivity degradation, do you still meet the PCT limit without any changes in the analysis method?

MR. ULSES: The answer to the question is that that's the assessment that the licensees have concluded and that's their conclusion, that they have again, they have -- one example, for example is these analyses are generally done in extremely limiting power distributions. But the plant doesn't generally operate at those power distributions and that gives them margin which is inherent in the -- and actually the other plant is analyzed versus how it's operated and that's one area that licensees have assessed and they've concluded that they have adequate margin.

MEMBER POWERS: If they're relying for the margin on quote "how they operate the plant," unquote, is that operational mode now move into the tech specs or something? I mean I can say yes, I've never operated in this mode so I have margin and tomorrow I change my operation mode.

How do you prevent them from changing the way they operate the plant?

MR. ULSES: Well, right now again, the way this is controlled, this is a licensee process; 50.46 has very specific requirements that the licensees have to follow. The NRC staff, as I said, is continuing to follow this issue and we are continuing to look into it, using the processes we have available to us. But as it stands right now, the licensees have made this assessment and they have concluded that they are operating in accordance with 50.46b requirements.

MEMBER BROWN: Do you all agree?

MR. ULSES: We have taken a look at the information that the -- we identified the plants that have a PCT in excess of 2,000 degrees. We have looked at those operability evaluations and right now the information in front of us we agree with their assessment.

MEMBER BANERJEE: With the EPUs that we approved, Tony, are they going back and evaluating the situation with regard to EPU conditions then?

MR. ULSES: They're evaluating the plant as it's currently operating, so the answer is yes. They're looking at the plant at EPU conditions based on their current analysis of record which would be done at EPU power. So, for example, the Point Beach example that was analyzed and looked at at its current operating power.

MEMBER BROWN: If I could just make sure I understand. They don't meet it on a design basis. They're depending on the operational mode that they're operating in in order to show that they've got margin, yet in response to the other question we're not aware of any particular operating tech spec or limits that have been put in place to ensure that they don't ever get into a condition outside of the operating mode where they've done their analysis for margin.

Is that -- that's all I've heard from talking to -- from listening to the conversation. Is that right or wrong?

MR. ULSES: The information again is what was done, was an immediate determination of operability which again took into account how the plant is operated versus how it's analyzed and that's what the licensee did, that's what they provided to us via resident inspectors at the sites. The staff at headquarters took a look at it and we concluded that we accept their immediate determination of operability. But as I said, we are continuing to follow this issue, using the processes available to us.

MEMBER ABDEL-KHALIK: Do you expect any tech spec changes to come out as a result of this?

MR. ULSES: Well, it's hard to say. I would say right now based on what we've seen I would expect at a minimum or what a site may have to do would have been taken and follow an approach similar to what you're going to hear today from staff and FPL. From what I understand, FPL has looked at their operating power distributions and is making changes to those as necessary. But that's one area that I think licensees have looked at and that's one area where I would expect to see if any changes I would expect to see changes there.

MR. HALE: Yes, if I could -- Steve Hale, Florida Power and Light speaking from the licensee's perspective. When an error of this type, whether its TCD or anything is identified, typically we have to do an evaluation. If the evaluation identifies a greater than 50 degree impact on PCT as a result of the error, whatever it might be, we're required to file a 50.46 report which specifically identifies restrictions and limitations that we have to impose and until we do a reanalysis, consistent with an approved evaluation methodology. So while there are interim positions that are established and it would be included in a 50.46 report, this is not the first time that an error has been identified that negatively impacts peak clad temperature.

MEMBER SIEBER: This analysis is performed at every reload safety evaluation as part of your reload analysis?

MR. HALE: No, not necessarily. Typically, what we do is we establish limitations.

MEMBER SIEBER: You use the box method?

MR. HALE: You develop a box and you ensure that you're within that box.

MEMBER SIEBER: Right.

MR. HALE: Now for our case, coming forward with a new license and action, our box has gotten a lot smaller as a result of the TCD issued.

MEMBER SIEBER: That's right. And for the next reload for every unit that's affected by this, that box will change.

MR. HALE: That is correct, until such time as a reanalysis or a new evaluation methodology is available to address it. I hope that helps.

MEMBER BROWN: No, I understand what you needed to do. My issue and I'm just trying to frame Dana's question about how does everybody know that they're bracketed or bounded -- they've got boundary conditions on their operations and it's known to the operators where they can go and where they can't go, while the analysis is being completed.

I'm not questioning the ability to do this. It's obvious you need to be able to do it. It was just what do you put in place to make sure you stay safe while all the i's are dotted and the t's are crossed.

MR. HALE: Understood.

MEMBER BROWN: And it's known to the people operating the plant. Thank you.

MEMBER SHACK: Mr. Hale, I think we can move on.

MR. HALE: Okay.

(Laughter.)

MR. HALE: With that, Mike?

MR. KILEY: All right. As Jason said, my name is Mike Kiley. I'm the Site Vice President for the Turkey Point Nuclear Plant. Again, I'd like to thank the ACRS for the opportunity to present the Turkey Point EPU.

At this point, I'd like to introduce the staff that we did bring this morning. So on my far left Sam Shafer. Sam is a current licensed SRO at the station with more than 25 years of operating experience at Turkey Point. Steve Hale, he's the Director of Licensing for the EPU. And to my immediate left is Carl O'Farrill. He's our Fuels Engineering Manager. So I'm confident with the staff we have here today, we can answer any questions that are asked.

So Turkey Point, I'm just going to give some brief introductions, Turkey Point is located about 25 miles south of Miami. It sits on approximately 11,000 acres and has 5 operating units and that's the numbering sequence that puts the two nuclear Units 3 and 4. So there's two fossil units that came on line in '67 and '68. Those are Units 1 and 2; 3 and 4 came on -- the nuclear units came on line in '72 and '73. And Unit 5 is a fairly new combined-cycle unit, 1,100 megawatts that came on in 2007.

The two nuclear Units 3 and 4, they're 3-loop Westinghouse PWRs with a Westinghouse secondary, currently producing 795 megawatts electric gross. That was the original AE, architect engineer for construction and design.

As I mentioned, Units 3 and 4 did come on line in '72 and '73. We did get the license renewal approved in 2002 and that brings the license out to 2032 and 2033, respectively. Like many plants in the industry, we have replaced our steam generators. The generators were replaced in the early '80s, '82 and '83. We did install two additional diesels, so we have four safety-related diesels at the station, uniquely designed that one diesel can maintain both units in safe shutdown condition. The heads, again like most of the industry, we did replace the reactor vessel heads in 2004 time frame.

So as Jason said, our original licensed thermal limit was 2,200 megawatts thermal. We did go through a 5 percent stretch power in 1996 to bring us up to 23. What we're here to present today is the EPU which would bring us up to 2,644.

So if there aren't any questions at this point, I'd like to turn it over to Steve Hale.

MR. HALE: All right, thanks, Mike. As Mike indicated, I'm Steve Hale. I'm the Licensing Director for the EPU effort at Turkey Point. As Jason summarized, we're doing a 15 percent total extended power uprate. Includes 13 percent EPU, plus a 1.7 percent measurement uncertainty recapture, the total being about 17 percent or 2,644 megawatts thermal.

Just some of the attributes of the Turkey Point extended power uprate, we are able to meet NPSH requirements for the ECCS pumps without any credit for containment overpressure. We're not making any mechanical fuel design changes for the EPU. And as Jason also mentioned, there were two other license amendments, the alternate source term which was approved in June, as well as the spent fuel criticality, revised spent fuel criticality analysis. And that amendment was issued in October of 2011.

We have completed all the grid stability studies, not only for the Turkey Point uprate, but as you'll be seeing some time in the future the St. Lucie extended power uprates, since they're all part of the same grid. And our current plan is to implement all of our final modifications for the extended power uprate for Unit 3 in the spring of 2012 and in the fall of 2012 for Unit 4.

I've included a summary. I won't go through these individually, but this just gives you a perspective on the changes in various parameters from the original through the stretch power uprate that was implemented in 1996 and for the EPU change. As you can see, we are -- we do have an increase in T av. We are taking credit for some of the margin and thermal design flow with reactor coolant pumps. You can see some of the other parameters we've indicated there.

Next slide.

This is a summary of the modifications.

Again, we went through this in some detail with the Subcommittee, so I won't get into specifics, just some of the highlights. These are the safety-related modifications we implemented. As Dr. Shack had mentioned, we did implement refurbishment on the auxiliary feedwater pumps. We are making some changes to main steam safety valve and pressurizer safety valve setpoints and we've implemented the leading edge flow measurement system which supports our NUR.

Next slide.

Looking at the modifications on the secondary side, we are implementing a new high-pressure turbine and the electrohydraulic control valves for the turbine. This is a major reliability upgrade for the plant. We are going to digital turbine controls. We'll be placing the MSRs in the condensate and feedwater system. We're actually replacing the main condenser and the condensate pumps and motors. We're upgrading the feedwater pump rotating assemblies and so on and so forth as you can see in those mods.

Next slide, please.

Again, going forward, modifications to the heater drains, a lot of this stuff is flow based, but we are looking at improvements and reliability by upgrading some of the controls.

Next slide.

And then on the electrical side, we are rewinding the electrical stator and we're also replacing rotor. We're including a number of other modifications associated with the generator modifications. We have replaced the iso-phase duct cooling system, upgraded it to provide additional cooling, providing upgrade cooling. We did replace the main transformers some time ago and we're upgrading the cooling there to address additional capacity. We're replacing the aux transformers and we're implementing some other special measures.

Just an update. We had five open items walking away from the Subcommittee. Three of the items will be addressed by the staff today. This is based on interface between ourselves and the staff. As Dr. Shack mentioned, the spent fuel heat exchanger license condition, talk a little bit about HELB and our loss of load analysis, our conservatisms associated with that.

MEMBER SKILLMAN: Steve, a question, please? I'm Dick Skillman. For the spent fuel license condition, does the approach that FPL is using ensure that the modifications are completed before you go into the next cycle with the higher percentage fuel?

MR. HALE: That is correct.

MEMBER SKILLMAN: Thank you.

MR. HALE: And then the two remaining open items you'll hear -- Carl will be addressing the thermal conductivity degradation and the amount of work we've completed over the last few weeks. As you can see with the documents we submitted, we've done quite a bit in addressing this particular issue and Carl will try to summarize where we stand with that.

And the other is the new fuel storage area criticality analysis. We submitted to the staff what they needed in December and that's still under review and hopefully, we'll be closed here shortly.

I know that was fairly quick, but if there are any additional questions, I'll turn it over to Carl for the safety analysis portion.

MR. O'FARRILL: Good morning. My name is Carl O'Farrill and I'm the Fuel Engineering Manager for Florida Power and Light. Today, I'd like to provide an overview of the safety analysis that was performed in support of the Turkey Point extended power uprate.

Some of the key changes that we made --

Steve mentioned some of the modifications that were made in order to accommodate the EPU which also were factored into the safety analysis, but some of the other changes that we have made, we have improved methods. Dr. Shack mentioned that as well. Key to that is that change from the CQD to the ASTRUM methodology would be a large break LOCA analysis.

We also made reductions to the peak heat factors, Fq, as well as F delta H and reduction in the actual offset operating limits for the plant site and these are the boxes we were talking about when we discussed the TCD. In fact, I'll get into that a little later on. The diesel boxes had to be reduced further in order to accommodate the impact of TCD in the large break LOCA analysis.

We made conservative assumptions for the physics parameters and assured ourselves that those would bound our future EPU core designs. We also included bounding, as typically done, bounding plant parameters in the analysis of assumptions, as well as conservative trip setpoints.

We maintain as per the Westinghouse methodology a conservative analysis limit, a safety analysis limit for the DNB requirement which provides considerable margin to the design limit for departure from nuclear boiling.

Next slide.

What we did here in these next few slides is look at the class of events and summarizing briefly the results from the limiting events for those particular class. And we'll just start to go through it. For the loss of flow or reduction in flow we have the loss of flow event as well as the locked rotor event. You can see that we had margin to the limits and those results.

With respect to overheating, the loss of load is the most limiting event for us and the minimal margin that Dr. Shack mentioned also that was discussed at the ACRS Subcommittee, but there are significant conservatisms in the analysis that lead to that result in which we bound all the operating parameters in a deterministic fashion. Everything is in the worst direction, all at the same time.

MEMBER SKILLMAN: Carl, I would like to ask a question about that, please. I see the communication from Steve Hale to Jason at the end of the year. And on the topic of conservatisms, we start from those conservatisms to get, if you will, the most accurate result with what I think you're communicating are the worst case beginning conditions. I would like to ask this question. In the December 29th email you sent to Jason, you said that you were going to use the nominal pressurizer pressure minus the uncertainty and the nominal pressurizer water level plus level uncertainty.

My question is had you used your highest pressurizer pressure and your highest pressurizer level, would you have exceeded your 2748 criteria for loss of load?

MR. O'FARRILL: I believe Ed Monohan with Westinghouse who provided me that input could address that specifically.

MR. MONAHAN: This is Ed Monahan from Westinghouse. We did look at those cases for other plants and for other analyses. And it turns out that actually modeling minus uncertainties on the pressure will give you a lower transient peak pressure once you run the cases.

So if we did model plus uncertainty on the initial pressure with a plus uncertainty on the level, we would get a better answer than what we're presenting here. I don't have that number with me right now, but that's what we found.

MEMBER SKILLMAN: I would like to ask for that, please, as part of the record. I would like to know that there isn't that case where you're entering what is basically a secondary load reduction and you're going in with your highest pressurizer pressure and you then worked your way through that. My sense is that you will end up with a higher reactor coolant system pressure than your analysis presently predict that you will.

MR. HALE: Yes, intuitively you would think that, but the input we got from Westinghouse was just the opposite. So we'll have them formalize that for you.

MEMBER SKILLMAN: Thank you.

MEMBER ABDEL-KHALIK: Is this an artifact of the reactor trip signal that actually shuts the reactor down in this transient?

MR. MONAHAN: This is Ed Monahan. Yes, I think it does have to do with the timing of when reactor trip occurs. There's a tradeoff between having a higher initial pressure. We tend to give you a penalty, but at the same time it can delay the trip which is on high pressurizer pressure. So there's a tradeoff and it turns out that the reactor trip aspect is actually a little more important and so the net result is a little bit answer when you do that.

MEMBER STETKAR: Suppose you take the

first trip though? Suppose you take it on turbine trip rather than waiting for the pressure? Then what happens?

MR. MONAHAN: Then you get a very good answer. You get a very quick reactor trip and the transient is gone. That's why we ignore that first trip.

MEMBER SKILLMAN: Thank you.

MR. HALE: We'll that action and get back to you.

MEMBER SKILLMAN: Thank you. Yes, sir.

MEMBER STETKAR: Steve, I wasn't at the Subcommittee meeting so this is the first time I've seen these numbers. The ATWS is that all valves open, the 3174? All safety, all relief valves?

MR. HALE: Yes.

MR. O'FARRILL: All right, next slide.

The over-cooling events and these are the main steam line breaks that are the limiting events. We did the hot full power as well as the hot zero power main steam line break. Previously, we had not had the hot full power main steam line break as part of our design basis, but in light of the EPU we included that as well. And we're showing margin to the DNB limits as well as to the linear heat rate limits.

I must point out here that we updated the slides for TCD, the analysis, and this slide did not get updated. We now have a linear heat rate limit, a power to melt limit, that is a function of burnup as well. And we went by and what this does is we verified that all the EPU designs are still satisfying that limit. So we have confidence that we can design under the new limit which is a function of burnup as a result of the thermal conductivity degradation on the fuel.

Next slide.

The reactivity addition and that's the rod withdrawal of power and the rod ejection events are the limiting events here. You see we still maintain margin to the safety analysis limit to DNB, so there's additional margins to the design limit in DNB as well.

For rod ejection, that was one of the events that was more affected by TCD and the reanalysis shows that we were still maintaining the margin to the limits for the deposited energy. We did see an increase in the amount of fuel melt as can be expected when we're accommodating the effect of TCD, but still within the limits.

MEMBER REMPE: How much of an increase did you see?

MEMBER POWERS: I have no idea what to do with these numbers. I mean the criteria is wrong. What do you do with that, Jack, live with it?

MEMBER SHACK: Same that we do all the time, just grind my teeth.

MEMBER BANERJEE: We had this problem before, Dana, I recall.

MEMBER POWERS: We always have this problem. When are we going to get the regulations on a scientific footing?

MEMBER BANERJEE: I guess Tony should answer that.

(Laughter.)

MR. CLIFFORD: Paul Clifford, Division of Safety Systems. We've had this discussion before. I'd like to reiterate that the Westinghouse 200 calories per gram is that of the upper threshold for coolability and our interim criteria in which we're currently applying to the new reactors goes from 235 calories per gram and it decreases with burn up. So with 200 calorie per gram upper limit on coolability, that's not cladding failure threshold, that's coolability, is actually conservative relative to all the data we have.

The other idea is they're using DNB as a figure of merit to determine the amount of cladding that fails for the dose calculations. And DNB has been shown to be very conservative for estimating the number of failed pans. Now there is another failure mechanism which is PCMI which is not represented in their analysis right now. And that's the value that is generally cited as about 150 calories per gram are changed in calories per gram in decreases with cladding hydrogen content. That's not reflected in their analysis right now.

MEMBER POWERS: So the question is why isn't it?

MR. CLIFFORD: The staff is still evaluating the data and we expect to go final with the PCMI failure threshold in the next few months. Right now, it's being applied to the new reactors only. We expect to retrofit it to the existing fleet. I would expect that we would have an update to the Standard Review Plan within six months or a year.

MEMBER POWERS: So these poor guys are going to go through another round of delay after that new Reg. Guide comes out?

MR. CLIFFORD: I wouldn't expect that it would -- the maximum total calories per gram they're predicting right there is 178. The change in calories per gram is probably around 150. So would they fail rods due to PCMI? Maybe. Would they fail more rods than they currently predict which is their does analysis is based on 10 percent? I doubt it because it's a highly localized transient. In order to get a high ejective rod you have to have a heavily-rodded core and you eject a rod. And only a small portion of the core itself experiences the power excursion.

So it's almost self limiting in a sense that it's difficult to fail a large percentage of the core because the remainder of the core remains in a rodded configuration. It's only the one single rod that ejects. So I wouldn't expect that the dose calculation would be affected.

MEMBER REMPE: You indicated that there's a change due to the thermal conductivity degradation and how much of a change was there before the other questions came up.

MR. O'FARRILL: Right, for the most significant change was in the amount of melt that we're seeing in the fuel.

MEMBER REMPE: And how much was that?

MR. O'FARRILL: And it went from around three percent to this eight percent value.

MEMBER REMPE: Okay.

MR. O'FARRILL: Next slide. We covered the non-LOCA events and now we're going to get into the loss-of-coolant accident events starting with the small break and these are some of the changes that we made to the assumptions, the changes to the plant to accommodate the EPU.

As I mentioned before, we reduced the power peaking, both in the hot channel enthalpy rise factor, the F delta H, as well as the axial offset. Steam generator tube plugging level was also reduced, compared to our current analysis of record in order to provide more margin, but one of the more --

MEMBER SHACK: That still has to be decreased again, right, for thermal conductivity?

MR. O'FARRILL: Yes. But small-break LOCA we did not have to do that, but for the large-break LOCA we had to decrease that limit that we had from 10 percent to 5 percent for the large-break LOCA.

The high-head safety injection pumps, we have a configuration where we share the four high-head safety injection pumps. It is recognized in our tech specs and so what happens is that we end up delivering tube flow from at least two high-head safety injection pumps to the affected unit that's experiencing the

LOCA.

The next slide provides the results from that analysis and shows that those changes were more than sufficient to accommodate EPU and we see a reduction from our current licensing basis, ECT, for the small-break LOCA.

Next slide.

These values, as in the other slides, have been updated for the TCD results. We're seeing a peak clad temperature of 2152 when we incorporate the effects of TCD and a maximum localized oxidation of 10.5. We're still showing considerable margin in the statistical approach from the 9595 value to the best estimate, if you will, 50th percentile of 1633 degrees PCT.

MEMBER BANERJEE: The degraded conductivity is not in there right now.

MR. O'FARRILL: Yes, it is.

MEMBER BANERJEE: The effect of the degraded conductivity is to have what, more stored heat?

MR. O'FARRILL: More stored energy in the fuel rods.

MEMBER BANERJEE: And also it comes out a little bit later, correct?

MR. O'FARRILL: Right.

MEMBER BANERJEE: The time constant changes. How much does it raise the value?

MR. O'FARRILL: What had changed from before, what we had to do here was also have some offsetting. So it's also factored in here.

MEMBER BANERJEE: So everything has been --

MR. O'FARRILL: That's correct. So we reanalyzed, we updated the analysis, factoring in the offsetting effects. And the major one was the power peaking that we did. We reduced from a 165 on the F delta H to 160. The FQ when from a 2.4 to --

MEMBER BANERJEE: So this is just a thought exercise. Let me ask, suppose you had not adjusted anything, how much did the temperature change?

MR. O'FARRILL: We'd be over --

MEMBER SIEBER: Yes, you'd be --

MR. O'FARRILL: We'd be over the criteria.

MEMBER BANERJEE: How much over would you go?

MR. O'FARRILL: I don't have that number. I don't know whether we --

CHAIR ARMIJO: We saw that number earlier.

MEMBER BANERJEE: Oh, you saw it?

CHAIR ARMIJO: Yes. I don't know if it's 23 something, in one of your documents.

MEMBER BANERJEE: But significantly over.

MEMBER ABDEL-KHALIK: Does this analysis have to be done iteratively? In other words you pick whatever results you want for the peak-clad temperature and you adjust your peaking factors accordingly to give you that result?

MR. O'FARRILL: No, that's not what we did. What we did was we looked at the peaking factors that we could live with and successfully design for for EPU. And so we lowered that, those peaking factors.

MEMBER ABDEL-KHALIK: That's different from what you said during the Subcommittee meeting, in a sense that you said at the time that you would pick whatever results you want and see what peaking factors would give you that result and then you design the core accordingly.

MR. HALE: This is Steve Hale. I just want to say it was a combination of both, okay? We certainly would not want to, as we indicated in the Subcommittee, we wanted to target 2150 as being acceptable or livable in terms of margin. But we also did not want to reduce peaking factors beyond the core as we currently have designed for Unit 3 and Unit 4.

So as a result, we looked at about where we wanted to be on peak clad temperature, but at the same time we had to ensure that whatever we reduced the peaking factors to, we could accommodate by the existing design cores that we have.

So it was a combination of both, really, but you know, we knew that the primary factor in dealing with this issue was going to be reducing peaking factors. And they kind of go hand in hand when you do the analysis because the results are directly tied to the power factors you assume and the effective TCD is tied directly to the power factors you assume. So you kind of have to do them in conjunction together.

MEMBER ABDEL-KHALIK: So it's fortuitous that you had already designed a core with a peaking factor of 1.6?

MR. HALE: Well, we typically --

MR. O'FARRILL: No, it wasn't fortuitous. We looked at the core designs that we did as a study for the EPU and we looked at what we could bring down and whether we could continue to bring it down even further as part of the initial run. So we ended up doing a one-time reduction. And it turns out that that's the results that we got from that. So we didn't do a lot of iteration on the peaking factors. We recognize that that was going to be beneficial.

We also made some changes to other input parameters to try to give us as much margin as possible so that we would be successful at that peaking factor.

CHAIR ARMIJO: Were all these changes basically core design, no changes in bundle design?

MR. HALE: No. It required no changes in bundle design. It was all core design.

MEMBER BANERJEE: And what sort of burn ups are we talking about?

MR. O'FARRILL: Well, when we did the large break LOCA, they do a sampling over the first burn for fuel rods. That's the approved methodology and it typically goes from around zero, fresh fuel, all the way to about 30,000 which is what you'd expect to see on a rod in its first cycle of burn.

But in recognition that we had a continuing degradation in fuel conductivity, we also looked at the second cycle and did an assessment of the second cycle burn and there, we have a burn down and that's typically what you see in normal operation.

In the second cycle, you'll see a decreasing power peaking in those rods as the burn up goes up. So we ended up crediting that as well and demonstrated to ourselves that we saw a declining trend that offset the effect of TCD in the second cycle of burn so that we were assured that the first cycle was going to give us the limiting results.

MEMBER SIEBER: Now you've had to struggle with margin for the next core because you already picked the core design before you knew what the envelop looked like. If future designs, future reloads, you'll have more latitude because you can adjust the enrichment of fresh fuel, the number of assemblies. And therefore, design into the reload pattern a less peak --

MR. O'FARRILL: Flatter core basically with less peaking.

MEMBER SIEBER: And so the situation that you're in right now is sort of unique to the circumstances under which the core design was done under an old regime of codes and then when you change codes, you find out you're missing some margin that you had to gauge, in fact, by analysis.

MR. O'FARRILL: That is correct. We did look at the current design that we already had in the books going into this --

MEMBER SIEBER: You already decided what it's going to be, right?

MR. HALE: But I would like to point out that these reduction in peaking factors are significant and they will impact our fuel costs and the number of fuel assemblies and things of this sort. And when we started out with a box, like you said, up here, we've crunched that box down that we're very tight and it's limited our flexibility in terms of on-going fuel cycles.

MEMBER SIEBER: Well, you save a few dollars on enrichment costs, but you spend money on fabrication costs and that lengthens your outage.

MR. O'FARRILL: Yes, the more fuel assemblies you put into a core design, the less efficient that core design is going to be, because you're going to get less burn up on that fuel and you'll be discharging it earlier.

MEMBER SIEBER: There's a lot of economic disadvantages, but some things you have to do.

MR. HALE: The ultimate plan certainly is for Westinghouse to update their codes to -- we're treating this relatively conservatively now in the interim until such time as Westinghouse updates their

PAD code to take this into account.

CHAIR ARMIJO: Could you explain why the 9595 maximum local oxidation decreases from 11 to 10.5 at the same time that the peak cladding temperature increases from 2040 to 2152? I would expect they would both increase.

MR. O'FARRILL: I'm going to have to defer to Cesare from -- my colleague from Westinghouse. If you could introduce yourself and respond?

MR. FREPOLI: Cesare Frepoli, Westinghouse. The reason you see the difference is more attributed to the different methods that were used. The 11 percent, pre-ASTRUM, was based on the CQD method. It is a rather simplistic conservative approach to maximum localized oxidation. With ASTRUM, we have the more explicit calculation.

In other words, we look at every single calculation from the sample, what maximum localized oxidation is so it's -- you gain so much in there. So that's why you may see a slightly lower value, even though the power is high and the temperature is high.

MEMBER BANERJEE: You mean that temperature and oxidation is not directly correlated?

MR. FREPOLI: We take a very conservative approach, actually. As part of the ASTRUM we use nonparametric tolerance limit and we don't take any assumption on how they are correlated. The mathematical assumption is actually that they are anti-correlated, therefore that's why we pick one out of a sample, 1 out of 24. It's the maximum for PCT maximal localized oxidation, correlated oxidation so that simultaneously you have a joint probability to bound a 95th quantile on the three attributes with 95 percent of ability.

MEMBER BANERJEE: So you found a way around Arrhenius' law by sampling?

(Laughter.)

MR. FREPOLI: What's the question?

MEMBER BANERJEE: Did you find a way around the Arrhenius equation by sampling, apparently, that's what it looks like.

MR. O'FARRILL: Cesare, I think he's asking is there a strong relationship between PCT and localized oxidation.

MR. FREPOLI: Yes, when you've brought them up there is indeed a strong correlation. I think the point that I was making is that we don't take credit of that correlation because if you will take credit of that correlation you will be able to look at lower of the statistics rather than the first one.

You may look at the second or the third one, which will give you more -- better results, I mean lower results.

MEMBER BANERJEE: I'm still puzzled. It's far enough away from the margin that I'm not too concerned.

CHAIR ARMIJO: Yes, it kind of makes you wonder about --

MEMBER SHACK: Well, they changed the law to things in going from one analysis to the other.

CHAIR ARMIJO: I know, we're trying to follow.

MEMBER BANERJEE: But you would expect the temperature and oxidation are correlation?

MEMBER SIEBER: Yes.

MEMBER SHACK: I don't think he's denying that.

(Laughter.)

MR. FREPOLI: No, I'm not denying that. I guess if I go back to the question as it started, the CQD as a simplistic was some sort of a recipe where the goal was to show compliance. So if you were able to get some very conservative bounding value, that was reported to say okay, it's 11 percent, that's 70 percent and we're fine.

If we ended up that the margin was not there, there was like a recipe where they're trying to sharpen the pencil and get the number better. So it was more like an iterative process, but you know, first year, second year, type of approach. With the ASTRUM, it's a more direct measure of that value.

MEMBER ABDEL-KHALIK: Does the change in peaking factors have an impact on rod worth?

MR. O'FARRILL: Well, core design has an impact on rod worth, but that's also one of the design parameters we go to to assure ourselves --

MEMBER ABDEL-KHALIK: Right, and the question then is did that have an impact on the results of your rod ejection accident?

MR. O'FARRILL: No, what we do in the other events is typically pick a bounding set of parameters including rod worth as part of that analysis to assure ourselves we're going to bound future core designs. So it would not affect that.

MEMBER ABDEL-KHALIK: So the timing of when these analyses were performed, the fact that you had already completed your rod ejection accident analyses before doing the large-break LOCA and changing the peaking factors doesn't have an impact on the results?

MR. O'FARRILL: I think you're touching on a point that speaks to the conservatism of the overall approach when we do these analyses. They're not necessarily related in that if I reduce peaking factors to offset some effect, to make sure that I get acceptable results in one event, I still pick conservative rod worth in this case for the rod ejection that bounds. So I don't ever want that event to have to be relooked at again when I do my core designs going forward. So I have something that's conservatively bounding, but yet still meets the acceptance criteria.

So I can have something that's not necessarily correlated and in fact, that is indeed the case for the rod ejection. We have very bounding parameters as to what we assume for the rod worth of the ejected rod, as well as the post-ejection peaking factors. And typically, what we have seen and when we compare ourselves to the EPU designs that we've looked at is we have considerable margin to those limits.

MEMBER ABDEL-KHALIK: Your peaking factor prior to the reduction that you introduced that is a result of the large-break LOCA was what, compared to 1.6?

MR. O'FARRILL: 1.65.

MEMBER ABDEL-KHALIK: 1.65.

MR. O'FARRILL: Roughly, four percent drop.

MEMBER ABDEL-KHALIK: Four percent. So your rod worth probably dropped by eight percent?

MR. O'FARRILL: It is also loading pattern dependent as to where you put that fuel assembly that has the peak hour relative to the control banks.

MEMBER ABDEL-KHALIK: Okay, thank you.

MEMBER STETKAR: Carl, I hate to do this because we're getting a little short on time, could you go back to Slide 20 and I have to apologize, like I said. I didn't attend the Subcommittee meeting.

I'm not sure I understand the plant. If I go to Turkey Point Units 3 and 4, there are -- I can touch a total of four high-head safety injection pumps between the two units. Is that correct?

MR. O'FARRILL: That is correct.

MEMBER STETKAR: With EPU, I've changed essentially my success criteria from one high-head safety injection pump to cope with a small LOCA to two. Back on Slide 17, the loss of load transient peak pressure, it's calculated as 2746 pounds. Does that include credit for the pressurizer relief valves opening or not?

MR. O'FARRILL: Yes, the relief valves.

MEMBER STETKAR: Not safety.

MR. O'FARRILL: No, the safety -- you're talking about the power operated -- no, it does not credit that.

MEMBER STETKAR: It does not. So in the real world they will open?

MR. O'FARRILL: Yes, that is correct.

MEMBER STETKAR: I'm thinking now about how much -- and in the Subcommittee did you talk about the effects of two units and shared systems? Because in the current design if I have a loss of offsite power, and I actually open the pressurizer relief valves and one sticks open on each unit because losses of offsite power will affect both of these units simultaneously, I still have margin because I only need one high-head safety injection pump on each unit and I have a total of four.

Now I have no margin because I need two and two. Did you look at all of that?

MR. O'FARRILL: Well, first of all, this is not a design change. This is design we've had originally on that --

MEMBER STETKAR: It's a success criteria change though.

MR. O'FARRILL: Crediting it in the safety analysis is the only change that we're doing here. There is no physical change to the plant.

MEMBER STETKAR: I understand that, but you need to credit two pumps in the safety analysis now and you didn't before.

MR. HALE: If I could, this is Steve Hale. The original plant design included two out of four. When we did the stretch power uprate including the tech specs, the PRA, all of that reflected two out of four. When we did the stretch power safety analysis in the mid-'90s, we assumed one pump versus two --

MEMBER STETKAR: Two out of four, putting the blinders on, assuming that this is a pipe break LOCA that occurs only at one unit, not a transient-inducted LOCA that could affect both units simultaneously.

MR. HALE: We do assume loss of offsite power on both units, but we do not take simultaneously LOCAs. That is correct.

MEMBER STETKAR: Okay.

MR. HALE: That was the original plant design. Now when we did the safety analysis for the stretch power uprate for the potential of reducing the reliance on the SI pumps, we assumed only one pump, but we did not implement any tech spec changes or make any changes with regards to success criteria and that sort of thing with the PRA. It's always been two out of four.

MEMBER STETKAR: Assuming a single-unit vent.

MR. HALE: Right, right. But that's the fundamental design, licensing basis for the plant. We do not assume simultaneous LOCAs. We do assume loss of offsite power with a --

MEMBER STETKAR: But relief valves always re-seat perfectly.

MR. HALE: I wouldn't say that.

MEMBER STETKAR: Okay. Anyway, I guess we're getting short of time so we should probably continue --

MR. HALE: I hope I answered your questions.

MEMBER STETKAR: Not completely.

MR. O'FARRILL: Just to get clarity on your question, you're asking for a dual unit event. Not only the loss of offsite power, but that the PORV is open, but they also --

MEMBER STETKAR: That's correct.

MR. O'FARRILL: Are struck open.

MEMBER STETKAR: Yes.

MR. O'FARRILL: So we have a failure of the PORVs in both units at the same time.

MEMBER STETKAR: I'm just trying to get a feel for what -- how much we've eroded margin because of the increased power level and increased injection requirements at the site, not looking at design basis analysis for a single unit in isolation.

MEMBER BANERJEE: So John, what's the probability that something will stick open, the valves. Is it fairly high?

MEMBER STETKAR: It's not, you know, I don't have the data right at my fingertips, probably once in a 100 to once in a 1,000 -- you know, they're not going to definitely stick -- you're not really even water through these things.

MR. HALE: Right.

MEMBER STETKAR: You're probably going to open, how many PORVs do you have?

MR. HALE: Two on each unit.

MEMBER STETKAR: Two on each unit. So they're both going to open under that transient.

MR. HALE: I would like to mention also that the staff did come to the site and we did do simulator runs on operator performance relative to stuck open PORVs and their response to those events. So that was one of the things they looked at.

MS. ABBOTT: This is Liz Abbott from FPL. In that scenario, the design basis is for a loss of offsite power on both units in a single failure is what's considered. So when we start postulating the loss of offsite power on two units and then failure of multiple PORVs to close, that's considered kind of behind design basis.

MEMBER STETKAR: I'm sorry --

MS. ABBOTT: We do have the capability to withstand it though because the operators are well trained that if they observe a PORV open when it should not be open, they would close the block valve. So there is design capabilities to address that circumstance.

And as Steve mentioned, that was one of the things that actually we did perform an audit and a demonstration on the simulator to show how quickly the operators do recognize that event and then mitigate that event by either manually closing the PORV itself and if that doesn't work, then they would immediately go to close the block valve. So it's a very fast transient. And that would occur based on our demonstrations in the simulator and the regular practice that the operators get, that would occur well before you would see safety ejection occur. Those trips basically occur before the safety injection actuation of settings, based on our operator performance and procedures.

MEMBER STETKAR: Turkey Point is fortunate because you have countable numbers of events for losses of offsite power. You don't need to be -- do big analyses to estimate frequencies. What fraction of the loss of offsite power events have affected both units versus only a single unit?

MR. HALE: We've had several. Over the last -- since 2000, I think this question came up at Subcommittee, we may have had two or three --

MEMBER STETKAR: They had a fair number before 2000.

MR. HALE: Before 2000, but we've been -- the grid has been pretty stable.

MEMBER STETKAR: Of those that you've had two or three, what fraction of them have affected both units versus only one unit?

MR. HALE: Typically, it would affect, if it's a system-related problem, it would be both units --

MEMBER STETKAR: I just wanted to get on

the record the fact that arguments if you assume a single unit loss of offsite power, the condition or likelihood of getting both units loss of offsite power is like one. If you have loss of offsite power, this is not an isolated -- especially with all of the shared systems on this.

MR. HALE: I believe Liz was talking about the combination of loss of offsite power plus single failures, plus another event is what she was speaking to.

MS. ABBOTT: Yes.

MR. HALE: And the probabilities -- they're very small.

MEMBER STETKAR: Have you done a dual-unit PRA?

MR. HALE: That question I can't answer.

MS. ABBOTT: I think -- this is Liz Abbott from FPL again. I think we do consider a dual-unit loss of offsite power. At the Subcommittee, we did provide the information on frequency that occurs. And actually we had two or three incidences and they were not both dual-unit events. They involved unit-specific equipment and not switchyard-related impacts. There was one that was a switchyard-related impact and we fully agree, if it's a switchyard-related impact, there's a higher likelihood that it would be a dual-unit event. But that -- there are other equipment-specific issues that could cause loss of offsite power that only affect a single unit. So that is not always the case.

And just to clarify, maybe I wasn't clear, but the single-failure criteria doesn't preclude the fact that our design basis is to consider the loss of offsite power as a dual-unit event. So you would consider a single failure and I think once again, we do have the design capabilities. The operators can manually close a PORV and they are trained to recognize that extremely quickly. It was a matter of seconds for them to recognize that when we demonstrated that in an audit in December with the staff.

And if the valve does not close based on the manual signal, the switch actuation that they give them, then the operators immediately go to close the block valve. And those are what are considered prompt operator actions that upon recognition and confirmation from a senior reactor operator on shift right there, they are able to perform that action without even having to bring the procedure out on the table and go through it.

MEMBER STETKAR: Was that audit done with a loss of offsite power in a single failure like a diesel?

MS. ABBOTT: That was not the scenario that was run. The scenario that was run was an inadvertent opening of a PORV.

MEMBER STETKAR: I can recognize that pretty quickly. I used to be an operator.

MEMBER SHACK: I think we're going to have to --

MEMBER STETKAR: Anyway, I just wanted to kind of pulse the dual unit effects because of -- and margin at the site basically.

MS. ABBOTT: Understood.

MEMBER ABDEL-KHALIK: Just as a follow up to this question, what signal gives you SI in this event?

MR. HALE: Which event?

MEMBER ABDEL-KHALIK: This loss of load or loss of feedwater?

MR. O'FARRILL: You wouldn't get SI.

MEMBER ABDEL-KHALIK: If you were to open the safeties, would you get SI on high-containment pressure?

MR. O'FARRILL: No, we would not, not for the --

MEMBER ABDEL-KHALIK: The PRT disc wouldn't rupture?

MR. O'FARRILL: No, as soon as you depressurize, the safeties would shut again and the same thing -- as designed, the PORVs would also shut again.

MEMBER STETKAR: As long as one doesn't stick open, you shouldn't -- you blow down a little bit and put PRT in it, it quenches.

MR. O'FARRILL: I think we were talking more of a PRA.

MEMBER STETKAR: It is, multiple failure is occurring.

MR. O'FARRILL: Slide 23. I think a lot of these points were already covered in the discussion either by the staff or during our discussion. The first slide is just a history that I think the staff covered pretty well through there that this is a new recognition that the impact would have been greater than previously thought.

CHAIR ARMIJO: Yes, I'd like to ask in view of the fact that we're going to have more -- this is not going to be the final meeting on this EPU and I guess the question to Bill is are we going to have a subcommittee meeting on the -- for example, of December 31 submittal? There are a lot of issues there. A lot of it is proprietary. Or is it planning to come back to the full Committee? Have you thought through what you want to do?

MEMBER SHACK: I had sort of assumed we would come back to the full Committee. Maybe after we hear the staff's discussion we can decide whether we need another Subcommittee meeting.

CHAIR ARMIJO: Yes, this is a pretty big submittal and a lot of questions in it.

MR. O'FARRILL: Yes, I guess we can go to Slide 25 and just go to that. And I think the purpose behind the slide is -- I wanted to indicate that as you saw from our submittal, we did a comprehensive look at it and we wanted to make sure that we looked at all the areas and plus on everything that could have been impacted by TCD. And as you would expect, we really just saw more of a localized effect from TCD on the fuel rod performance during accident analysis more than anything.

So many of these areas had either minimal effect, accommodated well within the margins of the analysis or no effect whatsoever. And that got us down to the next slide, Slide 26, as to where we did have some of the more significant impacts from TCD and it was in the fuel mechanical design rod performance codes. We talked about the power to melt limits now being burn up dependent. Rod internal pressure is also affected when you have higher temperatures in the fuel rod and the cladding strain and stress was also impacted and from the safety analysis standpoint, the non-LOCA one was the rod ejection and we did talk about that, and as well the large-break LOCA.

The last slide just restates what has been stated before as to where we are in this review process. That concludes my presentation. Are there any more questions?

MEMBER POWERS: When did Turkey Point do its last integrated leak rate test?

MR. O'FARRILL: I don't -- Steve, do you know the answer to that?

MR. HALE: We have someone here.

MR. TIEMEAN: This is Phillip Tiemean, Florida Power and Light. We did those during the head replacement outages in 2004 and '05.

MEMBER POWERS: So in a couple years from now you'll have to do another one.

MR. HALE: Any other questions from the Committee? All right, thank you.

MEMBER SHACK: We move on to the staff's presentation.

MR. PARKS: Good morning. My name is Benjamin Parks. I work in the Reactor Systems Branch in NRR. To my right here is Sam Miranda, also in the Reactor Systems Branch. We're also joined by Paul Clifford, Division of Safety Systems, and Len Ward in the Nuclear Performance and Code Review Branch and they are prepared to jump in if there are any questions in their area. We were all contributors to the safety review for the Turkey Point uprate.

And we're going to speak this morning about the safety analysis.

Briefly, to recapitulate what we covered during the Subcommittee, we had a couple of key focus areas for our safety evaluation and these included the main steam line break, the emergency core cooling system evaluation and the safety-significant events that were outside Turkey Point's licensing basis. Having been licensed prior to our issuance of the general design criteria and the more recent revision of the Standard Review Plan, there are some events that are not within their licensing basis that we asked about. These included the feedwater line break, the inadvertent opening of the primary relief valve, and the modes 4 and 5 boron dilution.

From those events which we covered in detail in the Subcommittee meeting, we wish to kind of reiterate the results from those and I think that there are three significant results. For the lower mode boron dilution events, the licensee ended up increasing shutdown margin requirements in their tech specs. The licensee was required to demonstrate operator capability to mitigate the inadvertent PORV event and the reason that that happened was because we asked for an analysis of this event and typically it's understood to be a DNV transient.

The initiating event causes a reactor coolant system depressurization. And the plots that we got showed there was a very strong insurge into the pressurizer right about the time that the DNV transient was over. So we asked about that because we didn't see the reactor coolant system effectively stabilizing at the end of the event.

And what we found out was and through our own thinking, the insurge was caused by some hotleg saturation or hotleg flashing that was occurring at the end of the event. And we also began to put together that because this unit has four high-head safety injection pumps that would begin to align and inject at the onset of a depressurization event like this, as the system depressurizes, you've got that much safety injection. So we asked about the pressurization aspects of this event, too.

What we found out was the pressurizer would fill at Turkey Point in about five minutes. However, we did go to the simulator and observed this event and the operators, given an instrument failure that causes the PORVs to open, the operators responded in about nine seconds to close it. It was a fairly immediate action.

So there was a lot of margin between the operator response time and the required response time as demonstrated by the safety analysis. Now having pulled that forward from Turkey Point that's also an issue that we'll be pursuing generically as well. It's sort of a lessons learned from the Turkey Point review that maybe there's some downstream effects from the inadvertent PORV that aren't necessarily related to the departure from the fleet boiling.

MEMBER POWERS: How do we extrapolate timing from a simulator to an actual control room operation?

MR. PARKS: We didn't extrapolate the timing. We wanted to see the operators' capability, once we knew what the acceptance criterion was and that was inferred from the safety analysis. And so the safety analysis showed that the operator response was required in five minutes under a set of conditions designed to deliver a pessimistic result which was fill the pressurizer as quickly as possible.

MEMBER POWERS: And you said that the operator in the simulation responded within nine seconds. And therefore, you assume that in the control room you would have margin. And what I'm asking is what was the basis, the technical basis for making that extrapolation? In other words, how do you know that the operator will respond in nine seconds in the control room or some small multiple of nine seconds and not in 309 seconds in the control room?

There must be some reason that you make that extrapolation. I just want to know what it is.

MR. PARKS: Right, because certainly, it's not exactly nine seconds and it's not going to be nine seconds every time. The licensee explained to us that this is not a procedure that they're required to look up. They're required to acknowledge it and respond immediately. So that's one bit of information that says that they're responsible, be expeditious. That's just not a quantifiable data point. We just know that it's going to be quick, based on that.

The licensee also assured us that they train on this type of scenario often, so we know that this is repeated in the simulator for all the operators as a part of their normal training. So that's another data point that says it's going to be a small amount of time because it's well rehearsed.

Then we saw the demonstration and that was nine seconds. And so that was confirmatory in the sense that we know it's a pretty small amount of time and then beyond that, had the event not gone as planned in the simulator, there are a couple other indications. They got an indication because the PORV actually opened. I think it was a position switch. But there are also tailpipe acoustic monitors and pressurizer relief tank sensors that would also alarm the operators. And if they failed to be successful at closing the PORV itself, there's also block valves that they could close. So there are a number of different ways that they could respond differently, but still, given the difference between nine seconds and five minutes, we deem that to be adequate.

MEMBER POWERS: That, by the way, was an excellent answer.

MR. PARKS: Thank you. And the final

review result was in the post-LOCA boron precipitation analysis, the licensee provided some analytic improvements. Dr. Ward did some of his own calculations to calculate the onset of boric acid precipitation and there was a difference in his analysis relative to Westinghouse's and that was that Westinghouse assumes basically pure water condensing and containment returning to the sump and Len's analysis assumes boric acid condensing in containment and returning to the sump which is a bit unrealistic, but it is conservative because you don't know how much entrained boric acid is going to return to containment and return to solution or be carried out through -- spilling liquid as opposed to vapor, etcetera. So Len's analysis is conservative in that respect. And the licensee improved its analysis and the results were very similar.

Now to the open items for --

MEMBER BANERJEE: Is there some assumption --

MR. PARKS: I'm sorry.

MEMBER BANERJEE: Is there some assumption about the mixing in the lower plenum calculation?

MR. PARKS: There is. The licensee assumes half of the lower plenum mixes.

MEMBER BANERJEE: Right.

MR. PARKS: And in Len's analysis, he doesn't assume that that happens until density conditions in the vessel actually warrant mixing in the lower plenum. So if you were to look at a trace of Len's analysis compared to the licensee's you would see that his has a spike and then it comes down, whereas theirs is a smooth curve. But it doesn't make a big difference in the overall result.

MEMBER BANERJEE: But the volume does, right? I mean if you didn't take -- let's say the licensee took a different fraction of the lower plenum being next, how sensitive is that? Do we know?

MR. PARKS: It's sensitive directly related a portion of the lower plenum volume to the total, right?

MEMBER BANERJEE: Yes.

MR. PARKS: And so if you reduce it, it will definitely affect your precipitation time and it will precipitate earlier.

MEMBER BANERJEE: If it's a third or a quarter or something rather than a half.

MR. PARKS: Absolutely, the results are sensitive to that. I believe based on the staff's review of experimental data, a half is a reasonable assumption right now. We don't have the best data possible. And I know that there is some testing, both with the Owners Group in concert with GSI-191 and internationally that the NRC is involved with to sort of refine those types of assumptions.

MEMBER BANERJEE: This should be for Turkey Point, but this is an issue which has come up repeatedly, the effect of scale on the volume that you can assume.

I agree that if -- whether you have the spike or not may not be a big deal, but the amount of the volume of the mixing is important. So we need to get a handle on that on a large scale probably.

Most of the experiments, I don't remember what the scale was. Somebody should remind me about the mixing. Maybe Len knows or somebody?

DR. WARD: Yes, Len Ward. The scale, I guess what --

MEMBER BANERJEE: What fraction -- sorry?

DR. WARD: There aren't many tests, but what the basis was that for was on some -- there was some European tests in Finland and there were some scaling issues. Some of the tests showed that the entire lower plenum contributed and other tests suggested that that wasn't true. And if you cut in half the lower plenum you would predict the data.

I mean as Ben mentioned, this is an issue that the Owners Group is looking at, boric acid precipitation methods, and one of the issues that we're requesting them to address is you need to identify how much mixing there is in the lower plenum and it needs to be based on some test data so that we can better understand how much actually contributes and what that contribution is. So that's something that's ongoing now.

MEMBER BANERJEE: What was the scale of the Finnish tests?

DR. WARD: There was -- I think one of them was -- I thought one of -- maybe I'll have to get back to you on that. I seem to recall that -- one of them was a full scale and the other one was a scaled test. There were mixed results. There were scaling issues and so that's why I said look, you can't take credit for entire lower plenum mixing. We're only going to let you go with half until you can do some testing later on and then show that if it's any larger than that, then you can take credit for it.

Right now, we allow them to credit half the lower plenum in the mixing volume. And as you said, it is very important. If you don't credit that, you can shift the precipitation time earlier by hours. So it's very important. But it's also important -- I've always had an issue with the vendors. They'll include that lower plenum mixing from time zero. Well, it won't contribute until the density in the core exceeds -- obviously. So you want to look at that spike.

There are some plants -- there are power levels and air boric acid concentration sources that affect that. You want to make sure that initial doesn't -- you don't precipitate because it can go upwards of 20 percent before it starts to mix. So it's important to be able to model it correctly so that you don't violate precipitation very early.

MEMBER BANERJEE: Thanks.

MR. PARKS: Okay, so on to the open items that we have within the Reactor Systems. The first is thermal conductivity degradation and I would like to clarify that there are two information notices about this issue right now. One is the one that we wrote in 2009 when we knew that there was a discrepancy between experimental data and the capability of the legacy codes.

And once we had a quantifiable result in the downstream safety analyses, particularly in the best estimate LOCA analyses, we issued Information Notice 2011-21, Realistic Emergency Core Cooling System Evaluation Model Effects Resulting from Nuclear Fuel Thermal Conductivity Degradation, and that was during the Turkey Point EPU review.

And so at the same time about, I guess two days before we issued this Information Notice, we also asked Turkey Point about the effect this would have on their LOCA analysis.

And the licensee in response has been working to revise steady-state fuel performance calculations and the ECCS evaluation to incorporate the effects of this. I briefed you on that earlier.

We took an action to discuss conservative analytic inputs in the reactor coolant system over pressurization analyses. And I think the key message there is that the over-pressurization analyses are deterministic analyses. They use pretty pessimistic inputs intended to deliver a bounding result, conservative high heat pressure. And I think that there's an interplay of the key phenomena.

Initial pressure, initial pressurization level, so you're talking about the mass in the RCS, how much liquid is there, how much enthalpy, and the reactor trip signal.

If you're responding to an anticipatory trip that comes in quickly, then the RCS initial conditions are very important. But if you look at a symptom-based trip like the RCS or the pressurizer pressure, then you're delaying that trip time until it gets so bad. And when that happens you add energy. And so the energy that you're adding to the RCS during that time becomes important. So there's an interplay between the two and that could cause the limiting set of initial conditions to change.

We had an open item with the spent fuel pool criticality analysis and this is a parenthetical phrase in the text specs that relates to the new fuel storage area and the staff is continuing its review of that parenthetical statement.

Open item resolution. The licensee has provided supplements describing the TCD analyses. I know that some Committee members, if not all of you have received those supplements, so you know what -- at a high level what's going on there. These supplements do include steady-state fuel performance calculations, transient accident analysis, impact assessments. Some results are a little bit different, and some changes to the realistic ECCS evaluation model.

In response to that, our review is continuing as follows. We are doing some confirmatory fuel performance calculations using FRAPCON. Paul Clifford is helping us out there. We're assessing the realistic ECCS evaluation model changes. We're reviewing licensee evaluation of remaining accident in transient analyses and we will issue a supplemental safety evaluation once we're finished with this review effort. And at a later meeting, we will brief the ACRS on the results and conclusions of our review.

So in conclusion --

CHAIR ARMIJO: Ben, when do you think you're going to be finished with that work?

MR. PARKS: My target to issue a supplemental SE right now is next Friday. Before we got the supplements, we also audited the licensee's efforts. So we know generally what's contained in the most recent supplemental although we haven't taken a detailed look at it yet. And in terms of the ECCS LOCA analyses, they had done in December a subset of 67 cases and we didn't think 67 cases of the realistic evaluation was enough, especially because it completed rescattered all the cases. The limiting PCT case wasn't the limiting PCT case any more.

In fact, there was very little correlation between the original and updated set of 67 cases. So in terms of the LOCA evaluation though those 67 were generally the limiting cases. Now they've done the additional 57 that are required to complete the set of 124, so the ECCS evaluation, we're not completely starting from scratch based on this week's supplement.

MEMBER SCHULTZ: And are the FRAPCON analyses already completed that are going to be used to compare against the licensee's calculations?

MR. PARKS: Sure. I'll ask Paul to speak to that. He's doing these calculations.

MR. CLIFFORD: Paul Clifford, DSS. I've completed the confirmatory calculations for rod internal pressure. But I'm still running cases to confirm the calculation of approached centerline melt and cladding strain during an AOO over-power event.

MEMBER SCHULTZ: When do you expect those to be completed?

MR. CLIFFORD: He says by next Friday.

(Laughter.)

MEMBER REMPE: All of this work about thermal-conductivity degradation is based on one test at Haldon with a lot of different types of fuel in that test. Could you comment about some of -- how would you characterize the uncertainty and results from that test?

MR. CLIFFORD: Degradation thermal conductivity is well established. It's not a single test. There are dozens of fuel rods on different fuel types.

MEMBER REMPE: At the Haldon facility, right?

MR. CLIFFORD: Correct, all at Haldon. Haldon has the unique capability of having centerline thermal couples where they can measure fuel temperature online.

MEMBER REMPE: But don't they use modified fuel rods where they have shortened the gap between the cladding and the fuel and --

MR. CLIFFORD: All that is taken into account when they determine what the conductivity is based upon, centerline temperature and operating power history.

MEMBER REMPE: And so I mean they say five to seven percent based on whatever, but what's the uncertainty? Have they -- can you characterize what it is? Are they ten percent off when you finally get this five to seven percent?

MR. CLIFFORD: Just to clarify, you mean the uncertainty in the Haldon data or the uncertainty to predict the Haldon data?

MR. FREPOLI: Uncertainty in the Haldon results.

MR. CLIFFORD: Well, any time you measure something, it's going to be some uncertainty to the thermal couples.

MEMBER REMPE: Right.

MR. CLIFFORD: Absolutely. But the trends are -- the trends are definitely there. I mean you can't argue with the trend and the decrease in conductivity as a function of burnup. Is there some uncertainty in the measurements, yes, but that's why you have a lot of data points. And you take that uncertainty into account when you put it into your design methodology.

MEMBER POWERS: Can we thoroughly expect degradation in thermal conductivity just on mechanistic grounds?

MEMBER REMPE: Yes, I just am kind of wondering. I mean you did say there were a lot of tests and I guess what I saw was that it was a lot of different types of fuel in -- wasn't it just one test or how many?

MR. CLIFFORD: No. I could provide you with the extent --

MEMBER REMPE: I've be interested in seeing the actual Haldon reports if that would be possible.

MR. CLIFFORD: Okay, no problem.

MR. PARKS: With that, that concludes the Reactor Systems Branch formal presentation. If there are any questions, we'd be happy to answer them.

MEMBER STETKAR: Ben, did -- I'm still trying to do back-of-the-envelope calculations here and things. Did you look at all at the dual unit effects?

MR. PARKS: You're talking about size systems?

MEMBER STETKAR: I don't want to focus on one particular system. This is obviously a plant that has some number of shared systems and we're reducing margin. Now the confidence in the reduction of margin if you look at an isolated single unit may be different than the confidence in the reduction if you look at events that affect both units. That's why I picked the loss of offsite power with stuck open relief valves. That's one. There could be others. Have you thought much about that?

MR. PARKS: In terms of the safety analysis, the units are typically treated as standalone units.

MEMBER STETKAR: I understand that.

MR. PARKS: Now one place where I did specifically consider it was in the LOCA analysis where the two out of four unit safety injection system is used. And the consideration that I gave in my review was Turkey Point has a unique tech spec requirement for a safety injection. All four SI subsystems must be operable and the only exception to that is to allow one SI system to be down while one unit is down so that they can remove it from service to do testing.

And so from our standpoint that means effectively there might at any given time be three SI units available. And so in order to comply with GDC-35, one of those would have to fail and so that leaves two available for our consideration in the safety analysis. So that's the way that we considered it there.

MEMBER STETKAR: And you said one unit has to be down?

MR. PARKS: Right, it's my belief that that tech spec, it's a limiting condition for operation and it applies so that the unit can be -- or the safety injection system can be tested.

Thank you very much for your time.

DR. BASAVARAJU: My name is Chakrapani Basvaraju. Technical Reviewer in the Mechanical and Civil Engineering Branch.

This branch is responsible for reviewing the structural integrity of the mechanical systems and components and to establish they are structurally adequate for the extended power uprate conditions.

There were two open items from the Subcommittee meeting regarding these mechanical components. One is the license condition welding for the SFP, supplemental heat exchanger. And the other one is the high-energy line break for the 6th feedwater heater nozzle zone of influence.

I will briefly touch on those open items. To maintain the design limits at EPU conditions, a supplemental heat exchanger will be added to the cooling loop of the spent fuel pool for each unit of the Turkey Point plant. During the review of the staff, I identified the design analysis of the modification of the spent fuel pool heat exchangers were not completed. Therefore, the staff decided to impose the following license conditions. The SER members wanted some clarification on license condition so we had discussions with the licensee and we modified the license condition welding to clarify that the -- all the modifications and installation associated with this key supplemental heat exchanger are completed prior to entering the EPU conditions. So that is the clarification we added here.

And then we required the licensee to provide the staff a summary of the structural integrity evaluations and margins associated with this modification. That's the evaluation for that open item.

The second one was related to the terminal end break of the nozzle of the 6 feedwater heater. The nozzle size has changed and there was some questions raised about the zone of influence and then we had further discussions on this with the licensee and some interactions and based on that, the licensee, based on the licensee's input, the licensee actually took a different approach than used the zone of influence methodology for EPU.

They took a very conservative approach and they decided to install a jet shield to complete divert the jet from the safety-related components. And the staff's review accepts the conservative position, so there is no zone of influence what it's usually called in the EPU of this terminal end break.

Next slide, please.

And the only one that's effective is this outside containment is this 6 feedwater nozzle the diameter had changed from 18 inches to 24 inches diameter.

Next slide, please.

The licensee performed walkdowns and they identified equipment important to safety and they protected all the safety-related equipment with a jet shield to divert the jet away from those components. The staff finds that the licensee has adequately addressed and evaluated this terminal end break at the outlet nozzle of 6th feedwater heater.

So that's in summary the resolution for the two open items of the Subcommittee meeting. Based on the review of the license's evaluation, the staff concludes that there is reasonable assurance that the plant's systems, structures, and component related to safety structurally adequate to perform their intended design functions for the EPU conditions.

That concludes my presentation.

MEMBER SHACK: Are there any additional questions for the staff? Okay, thank you very much. I guess the remaining open item for us is decide whether we're going to need a Subcommittee meeting to review this thermal degradation analysis.

CHAIR ARMIJO: Yes. It's a very complex submittal. There's a lot of material there. Maybe both the Fuels Subcommittee and Turkey Point --

MEMBER RAY: Bill, I was trading a note here with John, maybe I'm off base, but it seemed to me like this issue of shared systems that are both affected by a common cause event affecting both units is one I'm still wrestling with. And as to whether or not we've changed as a result of the EPU from a state in which operator action wasn't required as it is potentially after the EPU is the thing I'm -- I didn't go to the Subcommittee meeting, as you know, and I'm just hearing this for the first time and trying to react to it. But I would like to understand that better, I guess, somehow. Maybe I just offline get educated here. It's something I'm at least focused on, if I understood correctly.

There's a credible common cause affecting both units, loss of offsite power. And without the EPU circumstances would be one way and with it it would be significantly different. Now there's a level of confidence, response required under this hypothetical would be reliable, proven to be something we could count on, but still it's a delta that I'm not yet sure I understand why it's okay.

MEMBER SHACK: Okay, now is this in a PRA sense beyond design basis or on a safety analysis design basis sense?

MEMBER RAY: I think the latter. Just take for example one of the issues, not the exclusive issue, but one of the issues with CAV in my mind anyway is the dependence on operator action that is introduced in some cases, not in all. I understand the big difference between these things. But nevertheless, the greater dependence, I guess, on operator action would be a fair way to characterize CAV to maintain NPSH. And so that's one source of concern. There are others. But it's something that is similar in this instance in that the EPU triggers a need for operator action and I'm just wanting to be satisfied that that isn't something we've overlooked, that it's consistent with how we treat similar issues anywhere.

MS. ABBOTT: This is Liz Abbott from FPL. In our application, we address really two specific areas. One, the application addresses our licensing basis in a deterministic fashion and we summarized, and the staff reviewed the accident analysis portions of those. And those were done consistent with our licensing basis. And in a number of areas, we actually added additional evaluations and analyses that went beyond our licensing basis to expand the licensing of the plant.

In addition, in Section 2.13 of the application, we also assess the impact of the EPU from what I call a beyond design basis perspective or a PRA perspective. And there were a couple of questions earlier that perhaps maybe I could try to address. Our PRA is done for both units. It does reflect both units and in the case of the loss of offsite power it is reflective as a dual-unit event.

Turkey Point's PRA, because of some of these shared systems, we have an unusually low overall core damage frequency result from our PRA. We're about a decade lower than the average PWR plant and in Section 2.13 of our application, we did assess the impacts of the EPU from a PRA perspective as well. Those show that the CDF increase was on the order of 5 times 10^{-8} per year. It's an insignificant impact. Our baseline is on the order of 10^{-7}. And our LERF increase was on the order of 4 times 10^{-9} per year, so also what's considered an insignificant increase in risk.

Our numbers are particularly low in large part due to some of the common systems that we have and capabilities that we have. I think you may have heard earlier in the presentation the diesel generators, as an example. We have four installed diesel generators. On an event requiring a diesel to start, one diesel generator can actually carry the load of both units for our design basis events. So it really provides us a substantial improvement when you look at things from a risk perspective.

The safety-injection system that was mentioned earlier, where we have four pumps and in most accident scenarios one pump is all that's needed for success. Only the small-break LOCA is the one where we now rely on two pumps. That has been factored into these PRA results that were presented in Section 2.13 of the application. And we still show basically a very low risk profile for this plant. And those systems really help us out. Aux feedwater is another one that provides a particular benefit to this plant, that really puts us below the normal types of numbers that you see for overall risk on a unit.

MEMBER RAY: I've got to go to something here, but I'm not talking about risk base.

MEMBER STETKAR: Those dual-unit studies though, I still didn't hear -- they still focus on a single unit, presuming that the other unit is perfectly okay. Is that correct?

MS. ABBOTT: That's not true for loss of offsite power event. It is reflected that it's a dual-unit event and each unit is analyzed in PRA space, based on the capability and availability of the equipment that's present.

MEMBER STETKAR: Did you look at loss of offsite power which a stuck open PORV on each unit, yes or no?

MS. ABBOTT: From a Chapter 15 analysis --

MEMBER STETKAR: No, no, you said PRA. We're talking PRA now.

MS. ABBOTT: In PRA space, the failure probability of those valves would have been modeled and if that showed up as a cut set, it would have been reflected in the PRA.

MEMBER STETKAR: On both units?

MS. ABBOTT: I don't have the specifics of whether it shows up in the top 200 cut sets or so from a risk perspective. I do know the failure probability, you know, of our relief valves was on the order of 10^{-3}. They are very highly reliable. An opening of a PORV due to valve failure is not a Category 2 event. It is less frequent than that.

Typically, you're talking on the order of 10^{-2} for a Category 2 event. So it's a very low probability event. So you're talking just the dual opening or failure of two PORVs is on the order of 10^{-6} times per reactor year on event frequency.

MEMBER STETKAR: I'm not -- here's the scenario. Loss of offsite power requires pressure to increase in the pressurizer. PORV is open. One PORV sticks open on each unit and you have two diesel failures. Now they have to be the right diesels and they might be diesels -- I'm assuming you got motor operated block valves, not air operated or fail closed block valves.

The motor operator block valves, the diesel failures, if they're the right diesels prevent you from isolating the PORVs that are stuck open and if you have two diesel failures you don't have enough injection to have injection for the small LOCA on either unit. It's not a good day at the power plant. That's a two-unit event. You can't isolate it by looking at a single unit with single unit assumptions and it has nothing to do with PORVs failing to open on demand.

I'm curious whether this PRA, you might recognize this is not a risk-informed EPU. I'm simply trying to think about margins and one way of evaluating margins is to look at these kind of numbers. It's not a risk-informed EPU and I absolutely agree with you that in design basis single unit deterministic space you don't have a problem. I'm trying to understand kind of the broader picture at the site level.

And some of the numbers you were throwing around, I can't come up with just doing back-of-the-envelope calculations here on just simple --

MR. HALE: If I can just clarify something for the loss of offsite power dual unit? For Category 2 events, we're not allowed to fill the pressurizer. That's our limit. So by design, you will not open the PORVs on a dual unit loss of offsite power event. It would have to be a spurious opening of the PORV in order to do that.

MEMBER STETKAR: What's giving you the high pressurizer pressure then on your loss of load events?

MR. HALE: What's giving you the high pressurizer pressure? Reactor trip? I don't understand. Run that by me again.

MEMBER STETKAR: You have a loss of load on your Slide 17. Showed a peak reactor coolant system pressure of 2700 and some odd pounds.

MEMBER SHACK: Two psi margin.

MEMBER STETKAR: Yes, 2 psi margin. But it's 2700 pounds which is well above the PORV opening setpoint and you said well, you didn't take credit for the PRVs. What is the event that triggers that pressure increase?

MR. HALE: We're mixing apples and oranges. The loss of load event specifically does not allow you to credit turbine trip on a reactor or the first safety related reactor trip. That's a loss of load analysis specifically focused on sizing safety valves.

MEMBER STETKAR: Okay.

MR. HALE: Okay? I believe we were talking about a loss of offsite power event.

MEMBER STETKAR: Yes.

MR. HALE: Okay. Loss of offsite power event is analyzed as a Category 2 event.

MEMBER STETKAR: Right. I see what you're saying.

MR. HALE: All right, and for our acceptance criteria are very limited. You don't carry the event to the point that you're trying to challenge your safety valves. And just another clarification, there is no -- to the point Dr. Ray, I believe, we are not triggering any additional operator actions --

MEMBER STETKAR: Yes, I'm sorry, you had to leave, but I actually agree with you there. There is no new operator action as far as I can tell. That same operator action would apply regardless of EPU or not. It's a way to mitigate a stuck open valve.

MR. HALE: Exactly.

MEMBER STETKAR: I'm just worried about the increase in success criterias for a small LOCA, trying to think about transient-induced small LOCAs.

MR. HALE: I understand. I just wanted to explain that the loss of offsite power is different than this loss of load analysis that you were talking about.

MEMBER STETKAR: Okay. I'll have to think about that. Thank you. That helps.

MEMBER ABDEL-KHALIK: Mr. Chairman, Bill had to leave so at this time in the agenda we're supposed to ask if there are any public comments. Is there anybody in the room, a member of the public, who would like to make a statement?

Is there anyone on the phone who would like to ask a question or make a statement? Please, if there is anyone on the phone, please say something so that we know that the phone lines are open.

PARTICIPANT: No questions. Thank you.

MEMBER ABDEL-KHALIK: Okay. So if there are no questions at this time I guess we need to ask about Committee comments. I guess we discussed whether or not we need to hold a Subcommittee meeting before the next full Committee presentation which would likely be at the March meeting that we can probably discuss that at P&P and decide on that. At this time, we are at the end of the agenda and I would turn it back to you, Mr. Chairman.

CHAIR ARMIJO: Okay, very efficient, right on time. What we'll do is we'll recess and reconvene at 10:45.

(Whereupon, the proceedings in the foregoing matter went off the record at 10:31 a.m. and went back on the record at 10:47 a.m.)

CHAIR ARMIJO: Okay. We're back on the agenda. The next item is a briefing on the background of 10 CFR 50.46(c), the proposed rule and related activities.

So since I was Subcommittee chairman, I guess I can't turn this over to anybody.

(Laughter.)

So I'm stuck. We had I believe a very good Subcommittee meeting in December, covered not only the proposed rule but, at least at an overview level, the supporting draft reg guides to the proposed rule, and also an assessment of the ability of the U.S. fleet to comply with the acceptance criteria of the proposed rule. That required a voluntary effort and good cooperation between the staff and the industry.

Today I think, you know, we don't have enough time to cover all of that stuff. So Paul I think is going to concentrate, I hope, on the proposed rule and the assessment. But you are free to do whatever you want.

(Laughter.)

We did have issues that came up in discussion. I would like to compliment our staff for putting out a good set of minutes that I urge the members to take a look at, if they haven't already.

And with that, I would like to turn it over to staff. And I think, Bill, you wanted to take the lead on that?

MR. RULAND: Yes, thank you, Mr. Chairman. Good morning, everyone. The purpose of this briefing of course is to brief the full Committee on the proposed rule to 50.46(c). This proposed rule will eventually replace existing ECCS requirements. It is not an alternative to the existing requirement, nor will it be an optional regulation.

The main objectives of this rulemaking are to capture the research findings which identify new cladding embrittlement mechanisms and to respond to a Commission directive to develop a more performance-based ECCS rule. This rulemaking also responds to two petitions for rulemaking.

Both the ACRS Subcommittee and full Committee have been previously briefed on the LOCA research which comprises the technical bases for this rulemaking. In a letter to the Commission, the ACRS stated that this technical basis was sufficient and the rulemaking should proceed. Today's briefing focuses on the proposed rule language and the strategy for implementation.

To support the performance-based aspects of this proposed rule, the staff developed three new draft reg guides, which has also been briefed to the Committee. Upon the receipt of the LOCA research findings in 2008, NRR completed an initial safety assessment to determine the regulatory path forward.

When new information becomes available

which shows that existing regulations may not achieve their intended safety purpose, the staff must decide the speed at which the new requirements are imposed upon the industry. In 2008, the staff determined that no imminent safety issues existed for this proposed rule, and that the rulemaking process should proceed normally.

Recognizing that finalization and implementation of the new ECCS requirements would take several years, the staff decided that a more detailed safety assessment was necessary. So today's briefing also includes presentations by an industry representative about that safety assessment.

And, finally, I would just like to emphasize again that this is a proposed rule. Typically, it's slightly unusual of course for the Committee to have meetings on a proposed rule. And whatever comments the Committee chooses to make on this rule, which of course is up to you, would be -- stating the obvious --

(Laughter.)

-- is something -- you know, we are getting ready for the proposed rule stage, so we are going to be taking comments from the public. So, clearly, ACRS is part of that public. So if you do have comments, we sure would appreciate it. And if you don't, we have gotten lots of comments from you already.

(Laughter.)

With that, my opening remarks are completed, Mr. Chairman.

CHAIR ARMIJO: Thank you, Bill.

MS. INVERSO: Good morning. My name is Tara Inverso. I'm the Rulemaking Project Manager for the 50.46(c) proposed rule.

As Bill mentioned, the purpose of today's meeting is to present the 50.46(c) proposed rule to the ACRS full Committee. And then, Gordon Clefton is here from the Nuclear Energy Institute to review information contained in the pressurized water reactor and boiling water reactor owners groups reports, and that information was provided as a voluntary initiative as an alternative to a Generic Letter. And then, Paul will discuss the NRC's audit of that information and wrap up with an implementation schedule discussion.

The meeting will begin with this background presentation. Then, Paul will walk through the rule language paragraph by paragraph, and we will wrap up with Gordon and Paul's discussion of the safety assessment.

This rulemaking has many purposes. The first is to incorporate research findings. This research program focused on high-exposed fuel rods under accident conditions. It identified previously unknown embrittlement mechanisms and also expanded the NRC's knowledge of existing mechanisms.

And the biggest finding was that zirconium-based alloy claddings may embrittle at a lower combination of post-quench ductility and oxygen absorption than previously considered. As such, post-quench ductility might not be guaranteed following a LOCA under the current regulations.

It is because of that that the staff has concluded that this is an adequate protection rulemaking to restore that level of protection which the NRC thought was provided for in the current regulation.

We have Commission direction to do this rulemaking through SRM SECY-02-0057. The Commission told the staff to replace the prescriptive analytical limits with performance-based requirements, and also to expand the applicability of the current regulation. The current regulation is written to apply just to zircalloy and ZIRLO alloys.

There are two petitions for rulemaking that will be resolved with this rulemaking. The first is PRM-50-71, which was submitted by David Modeen of NEI back in March of 2000. And NEI requested in that petition to expand the applicability, much like the Commission direction.

And then, a second PRM was from March of 2007. It was submitted by Mr. Mark Lasey and requested rulemaking in a few areas, one of which was the consideration of thermal resistance of crud in the LOCA analyses.

We have had extensive public interaction throughout this rulemaking. It starts with the technical basis. The technical basis for this rule is in NUREG/CR-6967. And Research Information Letter 0801 points to and references NUREG/CR-6967.

We published those documents in July of 2008 for public comment. There was a public meeting in September of 2008 to discuss those comments on the technical basis. From there, an advanced notice of proposed rulemaking, or ANPR, was published on August 13, 2009. That ANPR had 12 specific requests for comment.

Nineteen entities submitted comment submissions. It was based on a variety of industry input, international community, and also public citizens.

There was a workshop on April 28th through the 29th of 2010. April 28th focused on the public comments received on the ANPR and the NRC's response to those comments. And the portion of the public workshop on April 29th was to focus on what the staff was calling at that point a prospective Generic Letter on the potential embrittlement of fuel rods.

And that is when the industry suggested that there may be another way to provide that same information that might be a quicker and smoother process, which eventually evolved into the owners groups reports that Gordon will talk about.

But three additional public meetings listed as August 12th and December 2, 2010, and March 3, 2011, were held to coordinate work on that report and to ensure that the requested information that might be in a Generic Letter was incorporated into those owners group reports.

We have been to the Advisory Committee for Reactor Safeguards multiple times this past year. And also, again in 2008, as Bill mentioned, we briefed the technical basis for the rule. Last year, in May and June of 2011, Michelle Flanagan from the Office of

Regulatory Research presented three draft regulatory guides.

Those draft regulatory guides are on conducting periodic testing for breakaway oxidation, testing for post-quench ductility, and establishing analytical limits for zirconium-based alloys. And those three draft regulatory guides will be published concurrent with the proposed rule, so that the industry and public stakeholders can comment on both the requirements and the regulatory guidance at the same time.

And the working group presented the proposed rule to the Subcommittee of the ACRS last December.

Back in the May and June timeframe, the staff had mentioned in its briefings to ACRS that we were considering possibly a new phenomena -- fuel fragmentation, relocation, and dispersal. The staff has concluded since then that further research is needed in this topic, but is recommending to the Commission that we proceed with this proposed rule, because it meets all of the objectives and is complete and should go forward to address the known embrittlement phenomenon.

The rulemaking schedule -- the rule is due to the Executive Director for Operations on February 29, 2012, and from there it will proceed to Commission review, and then, if voted on, public comment period.

Are there any questions?

MEMBER POWERS: Yes. What happens if you don't meet the February 29th date? Paul gets drawn and quartered or --

(Laughter.)

MR. CLIFFORD: Again?

(Laughter.)

MS. INVERSO: We are planning to meet it, so hopefully we won't find out if we're publicly hanged or anything.

CHAIR ARMIJO: Okay. Any questions?

(No response.)

All right. Let's move right along. Mr. Clifford.

MEMBER POWERS: I have one question. There is further research needed on fuel dispersal. Can you clarify what that further research -- I mean, what is the issue that you want to explore in that further research?

MR. CLIFFORD: Sure. There is significant data that has been compiled on fuel fragmentation.

Both in pile and out of pile integral LOCA tests have shown that fuel fragments potentially relocates within the enlarged blown region and potentially disperses out of the fuel rod.

But we don't have a sufficient understanding of the sensitivity of the fragmentation size to, say burnup, to really draw a line in the sand to say, "This is a limitation" or "this is how we would develop a regulatory requirement on how to deal with fragmentation."

MEMBER POWERS: Well, there -- I mean, in the issue of where things go, do you get an accumulation of particles in the balloon region? Do you throw things out the hole you have created? Those are very difficult.

As far as the size distribution of the fragments as a function of burnup, it seems to me that there have been some fairly sophisticated modeling that has evolved. Now, I have to admit nothing comes to mind of people doing detailed comparisons of size distributions versus what the models will predict.

MR. CLIFFORD: Right.

MEMBER POWERS: Is it that data comparison that you are looking for, or is it a phenomenological understanding?

MR. CLIFFORD: Well, the size distribution is the first thing that comes to mind, but you're right, it's -- there's many issues. Certainly, the uncertainty in predicting the transport of -- and the deposition of fuel particles throughout the RCS is a significant challenge.

MEMBER POWERS: But the transport issue -- I mean, the particles tend to be very, very large. So the only real issue is what the drag coefficient is.

MR. CLIFFORD: Well, I don't know how you define "large," but some of our tests the fuel particles look like gun powder.

MEMBER POWERS: Gun powder is very, very coarse.

(Laughter.)

I mean, Newtonian physics, I mean, you are not dealing with the problem of aerosols. You're dealing with the problem of rocks.

MR. CLIFFORD: Right.

MEMBER POWERS: Okay? And so the only question is what the drag coefficient is on the thing. And I would suspect you could use literature data to get drag coefficients close enough on that.

Now, whether it gets out into the channel at all to flow is one I -- I'm not familiar with anybody that has discussed that issue.

MR. CLIFFORD: Right.

MEMBER POWERS: And like I say, the modeling of the fragmentation -- I think there are some fairly sophisticated -- I mean, the problem is, you start fragmenting the first time you heat this fuel, take it up in power. And then, you start fragmenting it more every time you run a cycle --

MR. CLIFFORD: Absolutely.

MEMBER POWERS: -- on the thing. But the -- it's a decreasing return. I mean, it's not a linear function of burnup. And some of that has gotten very sophisticated in the modeling.

If what your concern is -- that had people taken those models and then actually looked at the fragments in fuel and compared the two in some profoundly strong statistical method, I'm not familiar with anybody doing that.

MR. CLIFFORD: Right.

MEMBER POWERS: And if that's what is missing, fair enough. Is that a hot -- hard job? And, yes, you need a real serious hot cell, which are becoming scarce as hen's teeth around this country.

CHAIR ARMIJO: Well, you know, I think the staff wisely decided to put that side for now.

MEMBER POWERS: Yes.

CHAIR ARMIJO: And I'm -- just my own opinion is I really don't see the down side consequences of some fragmented fuel coming out of the ballooned region, other than plant contamination. So, you know, possibly plugging up the strainers? I doubt that.

But, you know, I was just wondering what the staff is -- you know, I could ask the question: so what? You had a LOCA and you had a ballooned region, some fuel coming out of the ballooned region. What is the concern?

MR. CLIFFORD: Well, there are several concerns. The first is, how much additional fuel could be lodged within the enlarged balloon area, thus increasing the heat load?

MEMBER POWERS: Yes, that's an issue.

MR. CLIFFORD: One. And that would be if you had a very small rupture opening, so the fuel couldn't escape. If the fuel does escape, then you could have potential issues with energy addition to the system. I know you obviously already have a break in the system, so you don't have to worry about breaching your RCS pressure boundary.

But you are still adding a significant

amount of energy at a particular time during the transient. Could that affect the reflood, timing of reflood? And then, there's the deposition of the particles.

MR. RULAND: Paul, don't we ask a question about this topic in the proposed rule package? I mean, not specifically the technical part, but don't we ask a general question about proceeding with the rulemaking? I'm trying to remember.

MR. CLIFFORD: No, we removed that question.

MR. RULAND: Okay. Then, secondly, you know, if we need to have a separate meeting someplace down the road on this topic, since it is outside the current rulemaking we would be happy to do that.

CHAIR ARMIJO: Yes, yes. We will when you are ready with -- to talk to us about that. But for now let's just stick with what we've got.

MR. CLIFFORD: Okay. The purpose of this presentation is to describe the scope, structure, and basis of the proposed 50.46(c) rule package. Just as a reminder, the design function of the emergency core cooling system is to mitigate the consequences of a loss of coolant accident. Specifically, the performance objectives of the systems, structures, or components is to replenish the liquid inventory in order to maintain core temperature at an acceptable level.

The existing 50.46 rule dictates prescriptive analytical limits with no defined performance objective. To achieve the Commission's directive of a performance-based regulation, the working group started with a blank sheet of paper. As a result, 50.46(c) represents a major restructuring of the rule.

This slide shows an outline of the proposed rule. The existing rule is limited in applicability to lightwater reactors with uranium oxide pellets within cylindrical zircalloy or ZIRLO cladding. Hence, there is no ECCS regulatory requirements for a licensees opting for an advanced zirconium alloy such as M5 or optimized ZIRLO, nor are there any regulations governing the performance of new cladding materials during a LOCA.

The first step in the development of 50.46(c) was to define an expanded applicability. The rule is meant to be universally applicable to all LWRs, independent of ECCS design and independent of fuel design.

The second step in the development was to define principle ECCS performance objectives. However, since the performance of the ECCS will be judged on how well the fuel holds up under LOCA conditions, specific fuel design dependent performance requirements must also be defined.

For example, you would expect that the specific performance requirements for a ceramic UO2 pellet within a zirconium metal cladding would differ from the performance requirements of a metallic thorium-plutonium pellet within a ceramic cladding material. Therefore, the capabilities and capacities of the ECCS may differ based on the type of fuel for which it is trying to cool. However, the principle requirements are universal.

The third step in the development of this rule package was to define specific requirements for the current generation of fuel. Regulatory requirements of the ECCS consist of principal performance objectives, which are to maintain acceptable core temperature during a LOCA and to remove decay heat following a LOCA, and principal analytical requirements.

In other words, each LWR must be equipped with an ECCS capable of satisfying these principal performance objectives, and each licensee must provide a demonstration showing compliance.

For each fuel design, the rule must define specific performance requirements and analytical requirements which form the basis of the acceptable core temperature, which is the principal performance requirements. And that should be based upon all established degradation mechanisms and any unique features of the fuel in the core.

In addition, the applicant would need to define specific analytical requirements which could impact the predicted performance during a LOCA.

For current fuel designs consisting of uranium oxide or mixed uranium-plutonium oxide pellets within zirconium alloy cladding, 50.46(c) defines these specific performance requirements and analytical requirements based upon an extensive empirical database, including the recent results from the LOCA high burnup research program.

For new fuel designs, additional requirements may be necessary -- and additional research -- I'm sorry, additional research would be necessary to define all of the degradation mechanisms and any unique features of that specific new fuel design under LOCA conditions.

And then, new performance objectives,

analytical limits, and analytical requirements would need to be established based upon that research. As indicated in the previous slide, we have maintained several vacant paragraphs to accommodate future fuel design.

In this section, I'll walk through the language and discuss the regulatory and technical basis for each of the paragraphs.

Paragraph A, applicability. The revised text achieves the rulemaking objective to expand the applicability beyond zircalloy or ZIRLO and expands to encompass all LWRs. This eliminates the need for specific exemption requests for new zirconium alloys, which we have been granting for M5 and optimized ZIRLO.

Paragraph B, definitions. We added a definition for the new cladding embrittlement mechanism breakaway oxidation. I'm going to be moving pretty fast here, because we don't have a lot of time.

Paragraph C, relation to other regulations. The first thing you should notice when I show the text at the top of each slide is there is a gray text and there's a black text. The gray text is unchanged from the existing rule, so you can easily identify what has been changed. Here we just add clarification that the evaluation model needs to be approved.

Paragraph D, ECCS system design. Section 1 of this paragraph defines principal performance objectives and requires all LWRs to have an ECCS design to satisfy these performance requirements. And those are that core temperatures must remain below fuel-specific analytical limits and sufficient capability for long-term cooling.

The second part requires ECCS performance demonstration by use of the licensees. As with the current regulation, licensees may opt to either use an Appendix K model or a realistic evaluation model.

Item 3, this paragraph requires factors which impact predicted core geometry and coolant flow be included in the evaluation model. Fuel-specific factors would be defined in subsequent sections.

Item 4, this paragraph provides analytical requirements related to identifying the most limiting combination of break size and location. This is unchanged from the current regulation. New text has been added to clarify existing requirements, but the demonstration must cover the entire duration of the transient. Not a new requirement, just a clarification.

CHAIR ARMIJO: On that one, you know, the most severe loss of coolant accidents, does the issue of the transition break size being smaller than the largest pipe diameter impact this, or is it addressed in some way?

MR. CLIFFORD: Right. What we work on in 50.46(a)?

CHAIR ARMIJO: Yes.

MR. CLIFFORD: That is the optional or the alternative rule, which allows for risk-informed break size determination. That would replace this, so, yes, they would have different criteria for evaluating below the transition break size than they would above -- not different criteria, but different requirements for below the transition break size and above the transition break size.

CHAIR ARMIJO: So would this apply or not apply?

MR. CLIFFORD: Well, 50.46(a) is an alternative, so --

CHAIR ARMIJO: But if those chose that alternative, this is still mandatory or is it one or the other?

MR. LANDRY: Ralph Landry from the Office of New Reactors, which mind sound in congruence with what you are asking about. But I was on the working group that wrote 50.46(a) also in addition to 50.46(c).

The intent that we had when we wrote 50.46(a) was, if adopted, and then the acceptance criteria delineated in 50.46 were changed, as we are talking about with 50.46(c), the intent was to make 50.46(a) conform with 50.46 what is now (c) in the acceptance criteria for the break sizes below the transition break size.

Our intent was always to make the acceptance criteria in 50.46(a) below the transition break size identical to 50.46. The acceptance criteria above the transition break size would be relaxed. So we haven't gone back now and looked at 50.46(a) and made any conforming changes at this point.

CHAIR ARMIJO: Okay.

MR. LANDRY: But the intent was to make conforming changes should both rules be adopted.

CHAIR ARMIJO: Okay.

MR. LANDRY: Does that answer your question?

CHAIR ARMIJO: Yes, it does.

MR. RULAND: 50.46(a) has now been with

the Commission for over a year, and no action and no votes have been taken.

CHAIR ARMIJO: Yes. Well, some day they will address it. But I just wanted to know how it would fit with this rule.

Okay. Thanks, Paul.

MR. CLIFFORD: Okay. Item 5 simply provides a pointer to the analytical requirements which were -- which will be provided in subsequent paragraphs.

Section 3 of this paragraph defines required documentation. This section remains unchanged from Appendix K. It has just been moved up into the main body of the rule, so that it would be directly applicable to both Appendix K and to realistic models, which are outside of Appendix K.

Okay. Paragraph G specifies performance requirements and analytical limits used to judge the ECCS performance for the current generation of fuel. Peak cladding temperature is the first of five fuel temperature analytical limits associated with the principal ECCS performance objective to maintain an acceptable core temperature.

Research has confirmed the continued applicability of the 2,200-degree Fahrenheit limit on peak cladding temperature. It should be noted that PCT limit also prevents runaway oxidation and high temperature failure but is governed in this case by cladding embrittlement performance requirements.

MEMBER CORRADINI: Can you repeat that? I think I know it, but just say it again, please.

MR. CLIFFORD: PCT -- a limit on peak cladding temperature also prevents runaway oxidation and high temperature failure modes. But it is limited to 2,200 because of embrittlement concerns.

Paragraph G2, cladding embrittlement. This paragraph defines the preservation of cladding ductility as the performance objective. This is consistent with the basis of the current regulation. The rule and the associated reg guide capture the research finding, which is the new embrittlement mechanism we refer to as hydrogen-enhanced beta-layer embrittlement.

The paragraph requires the use of an approved analytical limit for PCT and integral time and temperature based upon an approved experimental technique. The staff has developed draft reg guides which provide acceptable analytical limits for licensees who do not want to perform additional testing. If a licensee opts to perform additional testing, the staff is also provided a reg guide which provides an experimental -- an acceptable experimental technique for conducting those tests.

CHAIR ARMIJO: Paul, just to make sure it's clear to everybody. If someone comes in with a zirconium-based alloy that is neither ZIRLO nor M5 nor zircalloy-2 or 4, but it's a dilute alloy --

MR. CLIFFORD: Right.

CHAIR ARMIJO: -- zirconium, it has not been tested in your test program, will they be obligated to do additional testing, or will they be allowed to use the same limits that you have prescribed?

MR. CLIFFORD: The reg guides provide specific guidance on that -- on that circumstance. It says that if you -- do you want to talk?

MS. FLANAGAN: You can go ahead.

(Laughter.)

MR. CLIFFORD: Okay.

CHAIR ARMIJO: If you need to caucus before you answer, it's okay.

MR. CLIFFORD: Okay. The reg guide provides specific guidance on that application. Essentially, they would have to perform a subset of tests to show that their alloy behaved in a similar manner to the larger empirical database, which is developed at Argonne. And if they could show that, then they would use the complete data set to develop analytical limits or they could use -- they could use our acceptable limits.

CHAIR ARMIJO: And because of the consistent performance among various alloys of very different -- you know, niobium versus iron chrome, and all of that, your expectation would be that they actually perform the same way.

MR. CLIFFORD: Correct. Our expectation would be to perform the same. However --

CHAIR ARMIJO: But they still would have to do a certain amount of testing to confirm that that is true.

MR. CLIFFORD: Correct.

CHAIR ARMIJO: Okay.

MR. CLIFFORD: The next item, paragraph G3, is breakaway oxidation. This paragraph is very similar in structure to the previous paragraph and captures the new embrittlement mechanism identified by the NRC high burnup LOCA research program.

It requires the use of an approved analytical limit on breakaway oxidation based upon an approved experimental technique which has developed and a draft reg guide which provides an acceptable experimental technique for measuring the onset of breakaway oxidation.

MEMBER SKILLMAN: Are there facilities available to validate a technique? In other words, if you publish this, have you not put the industry in a box where it can't comply because it doesn't have the access to the facilities that it needs access to in order to do the tests?

MR. CLIFFORD: This type of testing has already been completed at several independent labs, and we expect -- the reg guides are going out for public comment, and we expect we will get comments from the industry on their success at performing these tests. So they will hopefully scrutinize the level of detail we have in our experimental techniques and protocols for --

CHAIR ARMIJO: The staff, working with the industry, have created a round robin program among the different vendors and their laboratories to be sure that this testing works, that the different labs get the same kind of results as Argonne National Lab got when they did the testing.

So, yes, it is being addressed. We don't have the results yet, at least the staff -- ACRS hasn't seen the results of that round robin.

MEMBER SKILLMAN: Thank you.

MR. CLEFTON: This is Gordon Clefton from NEI. I can support that we do have the round robin in place. We have seven to nine invitations out. Many of the labs have come back and already started it. Our interest was to have the same testing criteria going into each lab but have different laboratory results.

In one of the ACRS meetings we talked about bringing the government's labs back into the round robin, and I think we agreed that it would be best to use that laboratory as a collection point of the results of the laboratory and do a comparison if there is a delta what existed previously rather than having a participation aspect.

We brought the thought to the table that the government lab would be an oversight of the other round robin results and those are in progress now. We have varying dates based on availability of the labs and cost resources available and such as that. So we don't have a firm schedule, because we haven't gotten response back from all of the labs. But it is in progress right now.

MEMBER SKILLMAN: Thank you.

MEMBER POWERS: The testing that you do here is on fresh clad, is it not?

MR. CLIFFORD: On breakaway oxidation, that is correct. And for post-quench ductility, it would be done either on fresh cladding, on fresh cladding that has been pre-hydrided, or on irradiated cladding.

MEMBER POWERS: Do you ever test cladding that has crud or absorbed boric acid in the oxide layer?

MR. CLIFFORD: Well, the testing that was done at Argonne included irradiated test -- irradiated samples. So they would have been --

MEMBER POWERS: Irradiated is not my question. It is kind of hard to understand how radiation affects things, because the interesting part of the oxidation, you probably annealed any radiation damage away.

The question is: suppose you absorb into the oxide layer these extraneous materials -- boric acid, cobalt, manganese, things like that. Does that create something unusual in the temperature ranges of interest? Or is the material kind of -- it neglects that? I mean, it is --

MR. CLIFFORD: With respect to the timing of breakaway oxidation?

MEMBER POWERS: That's right, yes, I mean timing of breakaway or the details of the kinetics and things like that.

MR. CLIFFORD: I'd ask Research to step in.

MS. FLANAGAN: So the question was whether or not there is -- oh, Michelle Flanagan from the Office of Research. And, Dana, your question was regarding the effect of different things that evolve over operating life, whether they have an influence on breakaway oxidation behavior?

MEMBER POWERS: Exactly.

MS. FLANAGAN: You know, I really don't -- I can't answer that question with what I know right now and the experience I have had with -- and the knowledge of the testing program. We have only done the testing on fresh cladding material. So there is --

CHAIR ARMIJO: And irradiated cladding, but under -- but in -- not under real conditions, you know, where there is boron floating around in the water and in BWRs.

MEMBER SHACK: That would be the ductility tests were done on fuel with service, so that --

MS. FLANAGAN: Yes.

MEMBER SHACK: -- but not in the breakaway oxidation.

CHAIR ARMIJO: But not fuel that had gone through a LOCA transient, a LOCA transient where you've got boron floating around. No, see, the issue is it would get heated up and go through that process during a LOCA, and did the boron get into the oxide and affect the properties. I think that is kind of what Dana is getting at.

MEMBER POWERS: Well, I mean, when you think about things like breakaway, you're thinking about things where the crystal structure might have changed and you create stress points that will cause rupture. And what kinds of things will do this?

Well, you say, gee, zirconium dioxide is an FCC lattice. So if I react it with manganese to create a porosite structure that is going to have a different crystal structure, and maybe it ruptures easier, or something like that. I mean, that's the kind of thinking you go through when you say, gee, what about crud, what about boric acid?

Boric acid creates an extended lattice, covalent bonding in the material, so you might think that has a different structure. And typically these are going to be more voluminous structures than an FCC lattice. And so you are going to create stresses in the oxide and maybe you get to breakaway easier or something like that.

Unfortunately, you know, if you were 500 degrees hotter, I would say, "Oh, absolutely, you've got to do this." If you were 500 degrees colder, I would say, "Absolutely, you don't need to worry about this." You are just right in my ignorance range, and I don't know whether you can get reactions at these kinds of temperatures.

MR. CLIFFORD: Well, during the Argonne program we did investigate the effects of surface roughness and pre-existing scratches in the cladding of various depths.

MEMBER POWERS: Yes, those all --

MR. CLIFFORD: We did not investigate impurities.

MEMBER POWERS: Those or --

MS. FLANAGAN: There is one element that was investigated that kind of speaks to what you are talking about, and that is some of the cleaning materials that were used on the surface, such as hydrogen chloride. We saw that that did have a big impact on the breakaway oxidation behavior. So we do know that there is a possibility to have an external --

MEMBER POWERS: Yes, the effect of chlorides on oxidation has just been known like since from the dawn of time.

MS. FLANAGAN: Yes, so we have seen the external surfaces have an influence. But the main effect on the breakaway testing was to distinguish --

MEMBER POWERS: I just would not make a leap that says that chloride -- because chloride has an effect, ipso facto then other things will have an effect. Chloride is such a nasty little bugger, and people have been so aware of it that -- to avoid it like the plague. It is not clear to me these other things have an effect. I just wondered if you had looked at it, and apparently not.

Okay. Fair enough. Put that on the to do list. Let's go on.

CHAIR ARMIJO: It's amenable to laboratory kind of testing, but it isn't easy to -- you have to --

MEMBER POWERS: It's one of those things that I would have to really think about how you actually do it. I suppose that if you were doing an autoclaving to create your oxide structure that you could do the autoclaving with a solution, and either a suspension or a solution to get it in -- it's not one of those things where you can just paint it on the outside and then heat it up. It's -- you've got to think carefully about how it gets where it's going.

CHAIR ARMIJO: And the kinetics have to be pretty quick, because you are talking a couple thousand seconds and everything is over.

MEMBER POWERS: Yes. I mean, it will either react or it won't. That's --

MEMBER ABDEL-KHALIK: So you're talking about building up a crud layer on the outside of the cladding, having that crud layer loaded with lithium metaborate to simulate conditions that may happen in a PWR?

MEMBER POWERS: I would be more concerned about things that could get into the pore structure of the external oxide over the course of 17 months of operation. And then, when I go through the transient, I get reactions that give me a volume change that create stresses in the oxide and have it exfoliate on me. It's the outside layer. The outside is the outside. It is already exfoliated out there. It has to be down into the pore structure of the oxide.

MEMBER ABDEL-KHALIK: And how thick would that oxide layer be for you to be concerned?

MEMBER POWERS: Well, I mean, these oxide layers form during normal operation for -- it depends on your alloy. For zircalloy, at the end of life fuel might run 80-micron thick oxide layer; for M5, what, 20-, 30-micron layer, something like that?

MR. CLIFFORD: That's correct.

MEMBER POWERS: And what not. I'm not sure the thickness of the oxide matters. It is whether you can get a stress riser due to a volume change of reaction from something in the pore structure.

CHAIR ARMIJO: Well, we did see that happen in -- due to crud with copper infiltrating the zirconium

MEMBER POWERS: Oh, yes, copper.

CHAIR ARMIJO: -- oxide that -- crud-induced localized corrosion effect during normal operation. And that really damaged the zirc oxide, and I would not want to have a LOCA with --

(Laughter.)

But, fortunately, that problem has been solved in the BWRs, and so that has been put to bed. But the basic question I think is a valid question.

My guess is it's -- you know, we haven't seen, other than that, infiltration or doping of the zirc oxide due to normal operation that is -- you know, from a post-PIE of fuel it would be -- and there has been a lot of fuel looked at, but maybe not as detailed as --

MEMBER POWERS: Yes, and the question is we look for the right thing. And I don't know the answer to this -- I do know that there is a lot of work now going on with people modifying FCC lattices with these -- in ADAMS to get these multi-phasic structures. And they are looking at it for ion exchange purposes. Here we would be interested more in how it affects the oxidation kinetics.

CHAIR ARMIJO: Okay.

MR. CLIFFORD: Okay. Item 4, maximum hydrogen generation. This paragraph limits the generation of combustible gas, which is hydrogen, and remains unchanged from the current regulations.

CHAIR ARMIJO: Paul, I've just got to go back to the breakaway oxidation, just to make sure that the people who were not at the Subcommittee hear the arguments on -- related to the testing and retesting requirement. Are you going to get to that in another paragraph on --

MR. CLIFFORD: There's a paragraph on

reporting.

CHAIR ARMIJO: Okay. Yes, because I've got a number of issues there. We elaborated on those issues in the ACRS minutes of the Subcommittee meeting, and -- but, you know, very few members were actually at the Subcommittee meeting. So I'd like to at least raise those issues at the right time.

MR. CLIFFORD: Okay.

MEMBER POWERS: You have chosen one percent again for -- you have changed -- it looks like you have changed the basis for the one percent, but it is one percent nevertheless. Why is one percent taken?

MR. CLIFFORD: Right. Well, it hasn't changed from the current requirement. You are wondering what the basis of the current requirement is?

MEMBER POWERS: Yes. I've always kind of wondered.

(Laughter.)

I believe that in the end the one percent was chosen to force a limit to the time that you could remain at the peak temperature. Okay? But I don't know that for a fact. I mean, it is my inference that one percent was chosen to constrain you from sitting at the peak temperature for a long period of time.

MR. CLIFFORD: I don't believe that's -- Ralph?

MR. LANDRY: Ralph Landry from the Office of New Reactors. Back in '72 and '73, when the hearings were underway developing 50.46, the belief was that if you could control the amount of cladding that would be reacted to, less than one percent of the total cladding material in the active fuel region, you would produce a quantity of hydrogen that would remain below the combustible limit in the containment atmosphere. So this --

MEMBER POWERS: No kidding. One percent would keep you well below combustion limits and --

MR. LANDRY: The purpose of the one percent is not a determination of oxidation of the cladding. The one percent is the equivalent amount of hydrogen produced, and the idea was to keep the amount of hydrogen produced, and a sufficient level of that combustion was not a major problem.

MEMBER POWERS: Yes, one percent certainly is going to keep you below combustion limits in just about any containment I can think of.

CHAIR ARMIJO: So, Paul, in your format this should be light gray.

MR. CLIFFORD: It should be gray. It should be gray.

CHAIR ARMIJO: Okay. Because that didn't change. Okay.

MEMBER POWERS: Well, I wonder -- I mean, in your spirit of generality, why don't you change this requirement to say, "Thou shalt not produce enough hydrogen to -- if I transfer it to containment that I would be over the lower flammability limit."

MEMBER CORRADINI: Wouldn't you have a problem, Dana, about concentrating and then showing how you distribute it and mix it? I mean, this one tells you that it is not going to be controlling.

MEMBER POWERS: I will always have the problem that if I take one percent and look at the break, it will be above the lower combustion limit. I will always have that problem.

MEMBER CORRADINI: But, I mean, another way of looking at it is this doesn't control anything. This doesn't affect anything. It is a -- I mean, the other question is: why even keep this at all?

MEMBER POWERS: No, no, I understand why they want to keep it. But I'm wondering, if you're trying to make this more general, and I look to issues like small modular reactors, you may be imposing on them in a way that you don't really want to do. I mean, from a safety concern, you are being way too conservative.

If you cast this requirement into one of thou shalt not get above the lower flammability limit in your containment, then it becomes more general.

MEMBER CORRADINI: More performance-based.

MR. LANDRY: But, Dana, this has not been a problem. This limit, going back through 35, 40 years of looking at LOCA analyses, we have never seen a LOCA analysis that even approaches a one percent core-wide oxidation level. So this --

MEMBER POWERS: I understand.

MR. LANDRY: -- this has never received a comment from anybody, because it is so low-ended the calculations don't even approach it. So it is really not a concern.

MEMBER POWERS: I understand. I'm saying you have not seen a LOCA analysis for the reactor that will be proposed to you in 2025.

CHAIR ARMIJO: Well, you know, that opens the other issue of mandatory --

MEMBER POWERS: You want it to be a performance-based requirement.

CHAIR ARMIJO: You could write it that

way, definitely.

MR. CLIFFORD: I understand. If they wanted it to be purely performance-based, then you would write what the performance objective was. And if it's to protect against a concentration that would ignite, then that would be the performance metric.

MEMBER POWERS: Yes. Some feedback to you, and take it for what it's worth.

CHAIR ARMIJO: That just reminded me of a question that came up in the Subcommittee meeting. This applies to all reactors, all LWRs. And we just are close to certifying the ESBWR design --

MR. CLIFFORD: Correct.

CHAIR ARMIJO: -- which never uncovers the core in these events. And then, so would the people who -- licensees of a -- operators of an ESBWR face a problem of everything, you know, related to cladding embrittlement, breakaway oxidation doesn't apply to them.

MR. CLIFFORD: I think their performance demonstration would just be that much simpler, because it wouldn't be challenged. But they would still need to provide a demonstration that it could meet the requirements.

CHAIR ARMIJO: Like what -- it is going to be an analysis. Hasn't that already been demonstrated in the certification process that these things are --

MR. CLIFFORD: Certainly.

CHAIR ARMIJO: -- you never uncover the core?

MR. LANDRY: Okay. I will put on the other hat. This is Ralph Landry from the Office of New Reactors. That very question came up during the review of the ESBWR because the plant never uncovers the core, and the criteria -- all five criteria at that time were looked at. We said there has to -- you obviously meet the criteria. Can we weigh something else? And at that point we said, "Well, you can show that you never drop below a certain level above the core. Therefore, that's an acceptance criterion for this design." So --

CHAIR ARMIJO: Okay. So, you know --

MR. LANDRY: -- you never uncover the core. These criteria don't mean anything.

CHAIR ARMIJO: Right. So the -- but this was a rule in the requirement for breakaway oxidation testing, qualification of the cladding material, new cladding material, embrittlement, all of that sort of stuff. Does it really apply? I would say no, but --

MEMBER CORRADINI: Well, Sam, isn't

another way of saying it is that they meet it easily by --

MEMBER SHACK: No, it comes back to this issue of testing. This -- that question came up at the Subcommittee. Bert Dunn wrote it up that -- for a guy that never uncovers his core, are you going to make him do a breakaway oxidation test?

MR. CLIFFORD: But they could set their time above 800 C to an enormous number. I'm sorry -- a very small number, so they could show that they are never going to challenge it.

CHAIR ARMIJO: I'm just saying, is there a way to --

MEMBER SHACK: But they still have to do the test to determine it. They can meet the criteria, whatever the criteria would be. The question is: do they have to keep doing the testing?

MR. CLIFFORD: Right now they would.

MEMBER SHACK: They would.

CHAIR ARMIJO: They would. You have to be reporting. They'd have to be reporting that they are --

MR. LANDRY: They still have the requirement of an approved fuel.

CHAIR ARMIJO: Yes, but they are --

MR. LANDRY: And the fuel designs for the new reactors are not using materials that are different from the fuels in the operating fleet. If a fuel vendor is going to make fuel for the operating fleet and for the new fleet, and it's the same fuel, they are going to be doing the testing.

CHAIR ARMIJO: It's not the testing, it's not the material. It's just the regulatory burden of a guy who -- it really isn't the same kind of reactor -- having to do stuff that is just a waste of time.

MR. CLIFFORD: Well, they could always seek an exemption to that reporting requirement, you know, as part of their DCD, one-time exemption for that type of reactor.

CHAIR ARMIJO: That's fair. They'd give you all of the arguments, and then you'd give them a one-time exemption and that's one of the benefits of that particular design.

MR. CLIFFORD: Right.

CHAIR ARMIJO: Okay. I understand.

MR. CLIFFORD: Okay. We have identified four previous temperature-related performance requirements for the current generation of fuel. The last one involves long-term cooling. The current 50.46(b)(5) states that, "After any calculated successful initial operation of the ECCS, the calculated core temperature shall be maintained at an acceptably low value, and decay heat shall be removed for the extended period of time required by the long-lived radioactivity remaining in the core." That's a quote.

However, no performance requirements or analytical limits are defined within the rule. So acceptably low temperature is somewhat arbitrary.

For 50.46(c), the working group decided to use the preservation of cladding ductility as a performance metric, the same as -- the same performance metric that is used during the initial stages of the LOCA.

The Federal Register notice includes specific requests for comment from the public and the industry on alternate ways to meet or define the performance metric for long-term cooling.

CHAIR ARMIJO: And the question came up, you know, how many days is long-term cooling? Or would that vary from plant to plant? You know, I saw some information that came back from the staff that said somewhere around 30 days, but maybe -- so is that what you are looking at as a metric, that they have to say you've got to maintain long-term cooling or cladding ductility for 30 days after the LOCA, or --

MR. CLIFFORD: Right. The 30 days isn't specified in the regulation. However, past practice shows that it consistently used 30 days in previous licensing actions. I think some of this was presented in the email we provided.

MEMBER CORRADINI: Thirty days is what was used in the certifications.

CHAIR ARMIJO: Yes, I think that -- so maybe that's -- but you are not -- you don't really specify that in the rule.

MR. CLIFFORD: It's a reasonable comment. Maybe we should.

MEMBER CORRADINI: Or at least put a pointer to where it is defined.

CHAIR ARMIJO: If somebody could come in and say, "Based on our analysis, 15 days is sufficient." The way this rule is written, you would have to evaluate that and decide whether that was okay or --

MR. CLIFFORD: Well, right now, they would have to define how they demonstrate that they maintain ductility through the 30 days. So they would -- I'm assuming they would run tests, and then show that -- define upper level on temperature and show that they stay below that temperature based upon the results of their experiments.

CHAIR ARMIJO: Okay. For the cladding alloys that you have tested to date, do you have enough information to say that that long-term cooling requirement is met for the materials in use today?

MR. CLIFFORD: The LOCA research program did not focus on long-term cooling. It focused on really post-quench ductility and breakaway oxidation. So there were no long-term tests run. So we have no new results from that test program.

CHAIR ARMIJO: So what would someone that is using conventional zircalloy-2 that has gone -- satisfy this requirement in the rule?

MR. CLIFFORD: Currently?

CHAIR ARMIJO: Yes.

MR. CLIFFORD: Okay. You would expect that they would provide you with the simulation of the transient out to a period of time, and you would show that the long-term ECCS delivery flow rate matched or exceeded the boil-off rate and that temperatures were continuing to decrease over a long period of time.

CHAIR ARMIJO: Or stay stable or decrease or --

MR. CLIFFORD: Right. Okay. No, a

second --

CHAIR ARMIJO: Okay. So it's an analysis, no testing required.

CHAIR ARMIJO: Right now, it is -- as I mentioned, it is kind of --

MEMBER SHACK: Did you have tests to accept the owners group proposed temperature that they -- limit that they had?

MR. CLIFFORD: That was -- in response to GSI-191?

MEMBER SHACK: Right.

MR. CLIFFORD: Right. There were proprietary tests.

MEMBER SHACK: Right. So, I mean, there is --

MR. CLIFFORD: Supplied by a vendor to -- and they specified a given temperature. It hasn't been adopted yet, but it is actually included in the question that's going out in the Federal Register. Should we adopt a limit such as that proposed? And what -- and could the test data be made publicly available?

CHAIR ARMIJO: Okay. Thanks, Paul.

MR. CLIFFORD: Okay. Paragraph G2 defines fuel-specific analytical requirements. The first item captures the research finding that oxygen ingress from the cladding ID surface promotes cladding embrittlement and reduces the allowable time and temperature to no ductility.

The second analytical requirement for current zirconium is that the effects of crud deposition in oxide layer must be considered in the evaluation model. This additional analytical requirement achieves the rulemaking objective to address the petition for rulemaking.

Appendix K -- moving right along -- use of NRC-approved fuel in a reactor. This paragraph clarifies the requirement of the use of NRC-approved fuel designs for which specific ECCS performance requirements have been established. It also recognizes the importance of leak test assemblies for collecting irradiated data to approve new fuel designs.

CHAIR ARMIJO: Which means that you could put in different materials without having to satisfy all of these requirements, because there is just, you know, a few assemblies and --

MR. CLIFFORD: Correct.

CHAIR ARMIJO: Okay.

MR. CLIFFORD: Within the bounds of the

plant tech specs.

CHAIR ARMIJO: Okay.

MR. CLIFFORD: Paragraph L, the authority to impose restrictions on operation. This is not a new authority for regulatory action. This paragraph just separates the authority between NRR and NRO, between Part 50 and Part 52 plants.

Paragraph M, reporting. The language in paragraph M has been significantly upgraded from the existing regulation in an attempt to clarify the existing reporting requirements. No new reporting requirements in paragraph M1 have been added, but the text looks significantly different, because we have clarified the various options for reporting with respect to an error.

CHAIR ARMIJO: I have a problem with this reporting requirement for errors or changes that don't result in any response that exceeds the acceptance criteria, and the error or change in itself is not significant. And then, there is a reporting requirement within 12 months, and there has to be apparently some sort of description of the change or the operation of the error.

Now, it is not significant in itself. It hasn't resulted in any exceedance of a limit. And the question I have is: it's not clear why an error that is so insignificant it doesn't need to be reported for 12 months needs to be reported at all.

MR. CLIFFORD: The reason for that is really bookkeeping and keeping a track on the evolution of an approved model. That they need to provide us with very rigorous validation of their ECCS models and we approve those. If they find a minor error and make a change to the model algorithms, then even though the result is insignificant being 50 -- change of 50 degrees, we want to be made aware of it and have the opportunity to challenge that.

CHAIR ARMIJO: But shouldn't that requirement be in the approval of that particular model and say, "This is the things we expect you to do as maintenance of the model," but not necessarily here in the --

MR. CLIFFORD: Well, without this reporting requirement, you would basically say that they would have to resubmit the entire model for NRC approval, and that takes a long time. So you would --

CHAIR ARMIJO: No, it's not for approval. You are just saying you want information, just to be kept up to date.

MR. CLIFFORD: Right. But if we didn't

have that reporting requirement, we would say you can only use an approved model with no changes. And if they had to make a correction, then they have to submit the whole model.

MEMBER CORRADINI: This makes sense, then, I think.

CHAIR ARMIJO: It's okay, but to me that is model maintenance. Why isn't that a requirement in -- when they approve a model? That's -- just keep us informed as that's part of your obligation in the approval of the model.

Why is it here in the law, the law of the land, reporting requirement with all of the bells and whistles related to it? And if something doesn't happen, there is violations and all sorts of stuff. It just seems to me like it's --

MR. LANDRY: Paul, if I may --

MR. CLIFFORD: Okay.

MR. LANDRY: -- Ralph Landry. The models that are reviewed and approved, a large part of that approval is based on the demonstration that the model submitted meets certain criteria and performs in a certain manner versus experimental data.

Now, if you make a change in that model, you either have to resubmit the model completely for the reviewed -- because you no longer have a demonstration of performance versus data that is valid, or we have to have some sort of mechanism to allow changes to occur without resubmittal.

And that is what we are doing with the reporting requirement. We are saying that if you make -- you are allowed to make changes up to a certain amount, and you have to tell us in 30 days. If you make changes that don't meet that trigger, then you tell us annually. But you have to tell us that you have made changes in something that we have reviewed and approved.

The alternative to a reporting requirement such as this would be, if you make a change, any change at all, you no longer have an approved model. You must now submit the model and the supporting proof of its validity for us to review and approve it. Review and approval of a LOCA model takes about two years or more. I don't think too many people would like to do that on a regular basis.

So the basis for the reviewing -- for the reporting requirement is it allows us to have changes made, corrections made, improvements made, without the entire material being reviewed again.

CHAIR ARMIJO: Okay. But, you know, my

issue is with things that are in -- not significant. And it is detracting from things that are significant, and you have different reporting requirements for significant changes that still don't violate the limits that are more than a certain temperature increase or ECR increase.

Then, you have reporting requirements and actions for changes that are significant and exceed the acceptance criteria and those are even more restrictive. To me, those seem pretty reasonably. It just seems like reporting of insignificant stuff is just make-work and a burden.

But you're telling me that, well, if we don't put it here, our regulatory process would result in something that is even more onerous than what this is. That's what I'm hearing.

MR. CLIFFORD: Correct. And also, it is really documentation. You wouldn't want them stepping 49 degrees every year, you know.

VICE CHAIR STETKAR: The cumulative effect of insignificant changes --

MR. CLIFFORD: Right.

VICE CHAIR STETKAR: -- at some point becomes interesting.

MR. CLIFFORD: We want to capture what the new analysis of record is. If it changes by 40 degrees, you still want to know what that is.

MR. RULAND: Right. This rulemaking -- this reporting requirement cannot be viewed in isolation. It is really in concert with our reviewing and approving the methods. It essentially is a permissive reporting requirement, and it maintains our integrity of the review and approval of the methods that we have done.

CHAIR ARMIJO: Okay. I have heard you, and I am not going to take any more of your time on that. And I also had an issue on your significance levels, although they have not changed from the -- at least the peak cladding temperature significance definitions. You have added the ECR significance definition --

MR. CLIFFORD: Right.

CHAIR ARMIJO: -- and I wanted to talk about that a little bit.

MR. CLIFFORD: Right. Paragraph M2, as you mentioned, we have maintained the 50 degrees as the threshold for significant, but we have also added a 0.4 percent ECR as a threshold for significant. And the purpose of this is you can imagine there is many changes you can make in a model that could affect the duration of the transient more than it does the peak in the first 50 or 60 seconds.

So this would capture both a change that affects the initial spike and a change that would affect the duration of a transient.

CHAIR ARMIJO: Now, I know it hasn't changed, but your -- the way you define the 50 degrees Fahrenheit change or error, it is a sum -- especially if it's an accumulation, it is a sum of the absolute magnitude of the respective temperature changes.

So if someone finds an error that resulted in a decrease in peak clad temperature of 25 degrees, and then made a change that increased the peak clad temperature by 25 degrees, is that a 50-degree -- a significant change?

MR. CLIFFORD: Right.

CHAIR ARMIJO: In other words, as far as margin to the limit, nothing has changed. But you -- everything is arbitrarily made non-conservative, even if in reality it is -- it is -- you are increasing or not changing margin.

MR. CLIFFORD: Right. Well, there is two reasons. The first reason is they find an error and it's 400 degrees. And then they say, "Well, I think there is some conservatism in this part of the model, so I'm going to take credit for that," and that compensates for it.

We want to be aware what sort of horse trading is going on, and how they are justifying that it may not be an immediate safety concern, because they are going to be going into the model and finding various levels of the --

CHAIR ARMIJO: Well, we've seen that earlier today. We've seen that earlier today at Turkey Point. That's why I wanted to get into this. And the question is --

MR. CLIFFORD: So if they say it's 300 degrees in a non-conservative direction, but then we have another 400 degrees of margin somewhere else, or so it turns out to be less than 50, whatever the delta is, we want to know how they are getting there. So you put the -- you know, the accumulation of the absolute value, so you know exactly how they are divvying up various conservatisms and how they are getting to the end point.

And as far as the change in either direction, that is just as important as a change in -- you know, going from 2,000 to 2,100. That's in the bad direction, but going from 2,000 to 1,900, and then increasing their tech spec peaking factors to allow them to go back to 2,000 is also in a non-conservative direction from a real work perspective.

CHAIR ARMIJO: Okay.

MR. CLIFFORD: So it's --

CHAIR ARMIJO: Paul, I don't -- if you are at 2,150, I can see where that 50 degrees, defined very conservatively, kind of makes a lot of sense. If you are at -- your peak clad temperature is at 1,600, you know, that 50 degrees F seems to be, at least to me, not important. And there is no flexibility there.

MR. CLIFFORD: Right.

CHAIR ARMIJO: It doesn't matter what your peak clad temperature is. You still have to do that and --

MR. CLIFFORD: Originally, we thought about a sliding scale. As you approach the limit, you would have more stricter reporting requirements.

CHAIR ARMIJO: And the same for --

MR. CLIFFORD: Far away, but it got very convoluted and very --

CHAIR ARMIJO: And the same for the ECR. There is -- you know, .4 percent ECR for some alloys is not much of an issue, but for others could be.

MR. CLIFFORD: Correct.

CHAIR ARMIJO: So -- okay. Well, look,

we'll move on. You have answered my questions.

MR. CLIFFORD: Okay. Item 3 -- and this will spark some debate also.

(Laughter.)

This is the new reporting requirement on measured breakaway oxidation.

CHAIR ARMIJO: Ah, that's the one. I knew you'd save the best for last.

MR. CLIFFORD: This cycle-specific reporting requirement is necessary to ensure that cladding alloy susceptibility to breakaway oxidation has not been inadvertently affected due to either planned or unplanned changes in fuel fabrication.

Wait for questions.

CHAIR ARMIJO: Well, you know, I think before I argue with you on that, I think I would like you to get through your what we call the performance safety assessment. I think that's very important, and it bears on this issue.

MR. CLIFFORD: Okay. That was the last -- we will be talking implementation maybe later. So next slide, next package.

Gordon is next.

CHAIR ARMIJO: Okay. Well, that's good. You know, this is a very important issue, and as far as the rest of this Committee's agenda this afternoon, it is our internal activities. And we are going to keep going until you are finished. If people choose to leave, shame on them, but -- they are free to do that, but I would ask you to stay, because I think this is -- a really good job has been done here, and I think we should focus on it.

All right. Gordon?

MR. CLEFTON: Yes, I'm Gordon Clefton from NEI. The slides I brought today are pretty much to support our conclusion from the industry that the safety assessment done early on was correct. What we found in the processing, working with management at NRC and with the industry, was there was going to be a significant impact on resources and expenses to do a response to a Generic Letter.

It was going to take a significant amount of time, and that didn't support the interests that Paul had with moving forward with this rulemaking or with what we had in the industry.

So when we heard that the NRC was proposing a Generic Letter to acquire a certain amount of information to support their safety assessment, I offered an alternative that I could coordinate the industry and the three fuel vendors to provide reports which would address and come up with the same information as would have been requested in a Generic Letter to support the safety assessment, that this is not a major safety issue and it can be implemented in a smooth and logical format.

So I coordinated the two owners groups, and I brought in all three fuel vendor suppliers. We had a multiple number of industry meetings, got authorization through the management of the owners groups, set an agenda, that matched what Bill Ruland and I agreed was acceptable, which gave us months of advanced information transfer over what a Generic Letter process would have taken, and we met our schedule, stayed on time, and provided the information in two separate reports, one from the boilers, one from the pressurized reactor owners groups.

Paul took those with the staff of the NRC and did an audit of the two reports, with cooperation of the three vendors. We did requests for additional information back and forth and satisfied the teams that did the audits on the two reports.

Our conclusions, if you go through here -- I don't need to talk about the history that we already mentioned with Bill and with Tara, but these are some of the references that you will have that showed the conservatisms we used, the grouping that we used.

In order to preserve the identity of each of the powerplants, we grouped to see which common factors might have influenced the margin that we had to peak centerline temperature. What we came up with was that there was basically no adjustment needed for the embrittlement breakaway oxidation on a number of the plants.

The remaining plants, which is a fairly small number here when you look at the numbers, took credit for various conservations. That's what Paul was talking about on the adjustments to margin for peak centerline temperature. These shared among the three vendors as much as we could with proprietary information, and then very specifics with the audit team that came from the NRC.

But we were comfortable that with our conclusion that all of the operating plants will show a margin now with respect to the new research findings concerning the hydrogen concentration in the cladding materials, and that we feel confident that the operating fleet can meet the proposed change in the local oxidation acceptance criteria.

Now, we have had a significant amount of interface 10, 11 years now. We started this in 2000.

We would like to continue that interface with public meetings, stakeholder involvement. And when Tara gets into the implementation schedule, you will see a need for windows where we have stakeholder input into the wording on the proposed rule and the three reg guides that are associated with it.

If there are any questions, I would be happy to answer. We've got the detailed reports right now and -- each of the three vendors to remove all of the proprietary information in it, so it can go into the public docket. We don't see any problems there. We had some medical histories. That slowed things down, the holidays slowed us down. There doesn't seem to be a rush, particularly on getting it back other than for the -- closing the loop of the process, but --

CHAIR ARMIJO: All the members have access to the --

MR. CLEFTON: That's correct.

CHAIR ARMIJO: -- version, so we appreciate that. And the other thing I wanted to make sure that the members knew, that in this assessment you -- all the research findings related to the influence of hydrogen related to the issue of fuel clad bonding. All of those things were incorporated into this assessment. So there was nothing left out. It was a pretty select -- gave you something to -- that you could count on, at least we're counting on it.

MR. CLEFTON: It was a rather unique project, if you will. And the fact that we had the cooperation of both owners groups, management associated --

CHAIR ARMIJO: And it saved a lot of time.

MR. CLEFTON: -- we estimate we probably saved $1.2 million at each of the utilities cross-country, so we are talking a net gain of probably $100 million or more by taking this alternate path.

CHAIR ARMIJO: Yes.

MR. CLEFTON: It worked well this time. The NRC did a parallel effort and did their generic letter preparations in case it was not -- our project was not as successful as it turned out to be. So that there was an opportunity not to have a time delay, the Generic Letter would have gone out.

We had conclusions that the alternate path worked very well. We hope to use this in the future if it's an opportunity.

CHAIR ARMIJO: Okay. Paul, you're on.

MR. CLIFFORD: Thanks. I'll be going into more detail of the safety assessment conducted by the staff and the information provided by the industry.

Okay. In this presentation, we will be briefly summarizing the research findings so everybody is on the same page, talking about the initial staff assessment that was done when the research became available and the more thorough plant-by-plant safety assessment which has recently been completed.

The Argonne research program identified three new embrittlement mechanisms. I'm not going to dwell on this, but this plot shows that the measured offset strain decreases significantly in high burnup zirc-4 versus fresh zirc-4. And it was determined that this was due to hydrogen, which is absorbed in the cladding material during normal operation.

This plot here shows measured -- this is the allowable oxidation limit to preserve a minimum amount of ductility as a function of hydrogen, and it shows the extent of the empirical database.

CHAIR ARMIJO: As compared to a straight line at 17 --

MR. CLIFFORD: Right.

CHAIR ARMIJO: -- 17 percent --

MR. CLIFFORD: Exactly.

CHAIR ARMIJO: -- across the board?

MR. CLIFFORD: The current regulations, it's 17 percent. So you can see even with small amounts of hydrogen it invalidates the existing regulatory limit.

Second embrittlement mechanism was that oxygen, which may be present in the fuel clad bond layer on the cladding ID, may diffuse into the base metal, reducing the allowable time and temperature to no ductility.

Third embrittlement mechanism was the degradation of the protective oxide layer, which is referred to as breakaway oxidation. As the oxide layer degrades, hydrogen is absorbed and it results in gross oxygen embrittlement.

CHAIR ARMIJO: I've been meaning to ask a question on that picture, because it is used all the time but as -- for a lot of reasons. But if you do breakaway oxidation on a test, let's say zircalloy-2, and it goes out for 5,000 seconds, and then it gets into breakaway oxidation, does it look the same as this picture?

MR. CLIFFORD: No. Would it look if we ran it even longer?

CHAIR ARMIJO: Well, eventually. Yes, sure.

MR. CLIFFORD: It may, yes, eventually.

CHAIR ARMIJO: But it generally doesn't.

MR. CLIFFORD: We would stop the test when we saw first signs of the degradation in the --

CHAIR ARMIJO: So this is breakaway oxidation, but it's a pretty gross thing. And this happened in --

MR. CLIFFORD: This is the old Russian alloy E-110.

MEMBER POWERS: This is E-110. This is the fluoride-contaminated or something like that.

CHAIR ARMIJO: The fluoride-contaminated, and that is why I want to get at the issue of the retesting, because I think it is driven by this observation and some other stuff that, you know, if you can scratch some stuff locally you can get breakaway there. But, you know, this is not typical or common or anything, but it just drives this requirement.

And that's where I have a problem, particularly where the times for breakaway oxidation shown here are 3,000 seconds, 5,000 seconds, greater than 5,000 seconds. And these are the alloys in use today.

MR. CLIFFORD: Correct.

CHAIR ARMIJO: And the durations of the LOCAs are 2,000 seconds, more or less. So you've got tons of margin, and the only way you can -- you can change that is by postulating that the alloy is so close to a cliff that slight changes in manufacturing procedures or processes or something like that, or alloys, will trigger breakaway oxidation.

And I'm telling you that doesn't make any sense. It's just not -- and so, you know, the problem here is you are requiring a lot of testing and retesting and reporting for something that is not likely to happen when you take into account the fact that the industry already does tons of testing to prevent these kinds of off-normal events in their factories -- you know, surface contamination, damage, and all of that.

And if you took a normal zirconium alloy, zircalloy-2, 4, whatever, contaminated it with fluoride, put it in a conventional water test or steam test used in -- to assure good corrosion during normal operation, which is a top priority requirement for fuel people, it would also be crummy. Okay?

So it's -- so the things that are causing breakaway oxidation also cause a great deal of damage to -- during normal operations.

MR. CLIFFORD: But E-110 had exceptional corrosion performance during normal operation. It was just when you got up to this temperature range of 800 C that it behaved like this in just a couple hundred seconds.

So without a requirement, how could we be -- how could we ensure ourselves that E-110 -- how do we know that it not going to creep into the --

CHAIR ARMIJO: E-110 fluoride-contaminated, in normal operating water, would be just as bad as the zircalloy-2 fluoride-contaminated normal operating water. These alloys aren't that different.

And, you know, the reality is that if this becomes a rule -- and it will, the breakaway oxidation is real -- fuel manufacturers will just add one more test to their standard set of tests that they do to assure a good corrosion resistance during normal operation, and that test will be the one that we use for breakaway oxidation.

MR. CLIFFORD: Right.

CHAIR ARMIJO: But -- and that will be a routine thing. Okay?

So now you are requiring a licensee to test each batch, and then report every time a new batch comes in for something that has tons of margin.

The phenomena is well understood, well under control, and will be tested anyway during -- in fuel factories in fabrication.

MR. CLIFFORD: I don't think --

CHAIR ARMIJO: And I think a national laboratory observation of a grossly contaminated sample shouldn't drive this regulation.

MR. CLIFFORD: I don't think --

CHAIR ARMIJO: That's really my argument.

MR. CLIFFORD: I don't think the staff position is that it is that well understood. And I don't believe the staff position is that it is only limited to the use of fluoride. So I don't believe that is our position. Our position is that there are potentially many suspect materials that could be introduced into the fabrication process that could promote early breakaway oxidation.

And we haven't performed enough of a sensitivity study to capture all of the potential alloying elements that could cause this. And because of that -- there is two ways of doing it, right? You could have a very, very, very extensive research program and test every potential alloying element and composition and show that it doesn't occur, or you could just say, "Run the test each time you manufacture a batch."

CHAIR ARMIJO: Well, the other thing you could say, "Look, you guys are going to be testing for it anyway in your fuel factories. Tell licensees to make that a requirement in their purchase specifications." And that will be that they buy material that meets the breakaway oxidation criteria.

And believe me, you get a lot more testing on a routine basis out of a factory than just one or two or three tests of a batch. A batch is a sample, doesn't tell you anything about how the process is changing. It is just really a poor way of getting information, and it flies in the face of a lot of experience in fabricating and testing zirconium alloys.

And I don't -- you know, I don't know what the fuel manufacturers or NEI's position on that is, but it seems to me like it is totally unnecessary.

MR. CLIFFORD: But, I mean, I will say one thing. It is -- the industry has been aware of these test results for many, many, many years. And to the best of my knowledge, they haven't updated their fabrication quality control procedures, to include this test, for any changes they make.

So they haven't taken the initiative

themselves, so it's almost as if they are waiting for the regulation to come.

CHAIR ARMIJO: Well, you know, I think they will. You know, the regulation -- they are going to do what they normally do.

MEMBER SHACK: If the regulation comes, they will.

CHAIR ARMIJO: But if there is no regulation -- but the regulation doesn't have to say "and it has got to be reported by the licensee," and all of that sort of stuff. It is just a matter of getting the licensee to make that a requirement, the breakaway oxidation resistance demonstration as a requirement for all fuel that they purchase, period.

MR. CLIFFORD: I think the industry also opposes, you know, the frequency of these tests, which would be for every batch. So I think when we go out for public comment we will be receiving a lot of comment from the industry, and they are free to propose an alternative, and we will weigh it based upon its merits.

MEMBER SHACK: That was my question. I mean, literally, every batch? I mean, couldn't you have, you know, every production run of tubing -- or you really want this done at the final stage after it has been through all of the --

MR. CLIFFORD: Well, we thought about, you know, whether it's an ingot or heat or whatever it is. But the -- it is only the licensee that the regulations apply to.

MEMBER SHACK: Right.

MR. CLIFFORD: So --

MEMBER SHACK: And he is going to stuff it back.

MR. CLIFFORD: -- if it crossed -- if he had an ingot that crossed -- you know, crossed licensees -- in other words, they generated so many for Palo Verde, so many for SONGS, I mean, how would you deal -- how would you deal with that? So it is really -- the regulations apply to the licensees, not the vendors. So we had to make it in some metric that is associated with the licensee.

MEMBER SHACK: No. But, I mean, will it be acceptable if the licensee goes back to the vendor and says all of this tubing came from this heat, you know, or this run, and it was all made the same way, whether it was for SONGS -- you know, so SONGS would go there, you know, Point Beach would go there, and they would just get a little certificate from the fabrication vendor. Would that be good? Or do they literally have to run their own tests?

MR. CLIFFORD: No, that would be fine.

CHAIR ARMIJO: Well, I tell you, I think there is a big misunderstanding of how fuel factories work. They work under a process control. Okay? And they process qualification, change control, and backing all of that up is a quality assurance program that -- looking at if things are changing, even though they are not supposed to be changing, something happened that was off-normal, nobody spotted it, the QA testing would spot it. And they do frequent testing, okay? Probably more frequent than if you just say, "Send me a breakaway oxidation test for that batch." Okay? And so you would actually get a better control.

But it seems that this is a normal fabrication kind of activity, and the process control is what you are counting on, because you can only sample. And if -- and as far as allow variability, you have already proven that alloy variability has no effect on breakaway oxidation, as demonstrated by these various alloys, very different alloys. And they all have long breakaway oxidation times beyond your LOCA duration.

So it really comes down to off-normal

factory problems -- contamination with fluoride, contamination with something else, oil. And all of that has been known for, as Dana said, for eons, and it is tested for.

All you're saying is, "Hey, we would like to see a test at above 800 C under the conditions defined in the reg guide." Fine. I think they do that anyway. It is -- to me, the way that you've got it, it is, one, ineffective; two, unnecessary. And it is -- and, you know, that's my point.

So anyway, I will stop.

MEMBER ABDEL-KHALIK: We already said that NRC would find acceptable the tests performed by those manufacturers who would provide a certificate to the licensee saying that such-and-such test was performed.

MR. CLIFFORD: Absolutely.

MEMBER ABDEL-KHALIK: So I don't know where your objection comes from.

CHAIR ARMIJO: It's a process qualification. You know, if the fuel manufacturer supplies to the licensee, this is the fuel you bought, it conforms to the following requirements in your purchase order, blah, blah, blah, blah, which includes a breakaway oxidation test. That's it. It is process control.

And that thing is sufficient, rather than a batch-by-batch test and tracking each batch. You are implying that these products are so variable and so sensitive that you've got to be watching them on a batch-by-batch basis. It's just like --

MEMBER SHACK: Well, I think the answer I sort of got from Paul was that the licensee obviously has to do it on a batch basis, because that is how he gets his stuff.

CHAIR ARMIJO: No.

MEMBER SHACK: The vendor --

CHAIR ARMIJO: He buys a batch. A manufacturer makes tons of cladding.

MEMBER SHACK: Right, right.

CHAIR ARMIJO: Some of it goes to this guy, some of it goes to that guy, some of it goes to that guy. But then, the certificate goes to different --

MEMBER SHACK: Goes to every guy.

CHAIR ARMIJO: But the manufacturer has qualified his process, and he is providing a qualified product to the licensee. So the acceptance of the manufacturer's qualification process by the licensee should be sufficient for the NRC.

MEMBER SHACK: But we don't regulate their fabrication quality assurance program.

CHAIR ARMIJO: You do monitor the -- somebody monitors the fuel factories, and you get updates and all of that. And I don't know what they report to you and what they don't report to you, but you don't get -- you don't require batch-by-batch reports on space or hydrogen pickup. You don't provide batch-by-batch requirements on Inconel stress relaxation properties.

All of these things -- there's tons of things that are measured and provided in a fuel bundle that are important, very important, and can cause problems that are not regulated. And I don't see this as any different. In fact, less --

MEMBER SHACK: Well, this is only a proposed rule, Sam. We are going to get lots of comment, as I said, from --

CHAIR ARMIJO: Well, you are getting some.

MEMBER SHACK: -- the real world.

(Laughter.)

CHAIR ARMIJO: You are getting one now. Okay. Well, then, I just -- I've made my speech. Thank you for listening.

Okay, Paul.

MR. CLIFFORD: Okay. Reaction to new

research findings. The response to the staff to new information depends on how you answer four basic questions. Are the research findings credible? Is the research complete? Are current regulations adequate? And is there an imminent risk to public health and safety?

When RIL 0801 was published, NRR completed an initial safety assessment. This was in July of 2008. And we concluded that due to measured performance, realistic rod power histories, and current analytical conservatisms, there is -- sufficient margin exists for the operating fleet.

And so we concluded that there was no imminent safety risk, that we should proceed with the rulemaking process, and we also identified some additional research needs.

So if we go back to the previous slide, was the research findings credible? Yes. Is it complete? It was complete. Are current regulations adequate? We determined they weren't, because the allowable ECR dropped below 17 percent, a relatively low hydrogen pickup. And is there an imminent risk to public health and safety? We concluded there wasn't.

However, recognizing that this rulemaking process takes many years and the implementation throughout each and every reactor would take many more years, we decided that a more robust safety assessment was needed. To support that, we developed some basic ground rules. The first is that we would develop an alloy-specific post-quench ductility analytical limit.

As you remember, the empirical data shows that there was not a strong alloy dependence on the allowable ECR as a function of hydrogen. But there is a strong alloy dependence on the rate at which hydrogen is absorbed by each of the alloys.

So this plot would show how even a straight line would turn it into a family of curves based upon the hydrogen pickup fraction of each of the alloys. In addition, one of our ground rules was that the cladding out of the oxidation would need to be considered above 45 gigawatt days, and that the alloy-specific breakaway oxidation would be judged against time above 800 degrees C.

Looking just at what the analyses of record in the plant FSARs are, we notice that there is at least 40 plants that are calculating less than three percent ECR. There's about 25 plants between three and six percent ECR, and then the remainder of the fleet is between nine and -- really, it's between nine and 17 percent ECR.

This gives you an idea of the magnitude of the change in ECR relative to the entire fleet.

If you look at breakaway, the calculated time above 800 C, over 60 plants only remain above 800 C for less than 500 seconds. There is about 30 plants that are between 500 and 1,000 seconds, roughly 10 plants that are between 1,000 and 2,000 seconds, and there is only one plant that remains above 800 C for more than 2,000 seconds.

CHAIR ARMIJO: And that is one little BWR-2.

MR. CLIFFORD: Right. Okay. I think Gordon touched upon some of these numbers. The revised post-quench ductility analytical limits -- 65 of the 104 plants met the required -- required the new limits based on the alloys that they have in their reactor, with no adjustments or new calculations needed. That represents 77 percent of the BWR fleet and 55 percent of the PWR fleet.

It is worth saying that all of the plants continue to satisfy the 2,200 degrees Fahrenheit, and realistically you could say that most plants are PCT limited and not ECR limited.

Eight of the BWRs performed new LOCA calculations, which credit existing tech spec thermal mechanical operating limits, which is essentially, as this plot shows, it is a limitation on allowable linear heat generation rate as a function of exposure. So crediting existing tech spec, they reran their LOCA analysis and they show that they met the current -- or they met the research data.

So no conservatisms, no analytical credits, they just said, "How can my plants possibly operate? It is limited by tech specs. If I take credit for the existing tech specs, I meet the requirements."

CHAIR ARMIJO: So they'd get into trouble -- if they were operating at higher powers somewhere out there there would be issues above this that would --

MR. CLIFFORD: Right. This tech spec would be governed by thermal mechanical, probably rod internal pressure. So if they exceeded -- if they exceeded at high burnup, exceeded this rod power, then they would potentially burst rods due to rod internal pressure.

CHAIR ARMIJO: Okay.

MR. CLIFFORD: The PWR side, 31 of the PWRs either performed new calculations or identified some credits within the current approved methods.

Nine PWRs -- and there is a breakdown. Nine of them performed new calculations which credit rod power history, similar to what the BWRs did. Eleven of them credit a transition to an approved -- improved evaluation model, but it is also an approved evaluation model, just not applied to this specific plant.

MEMBER POWERS: It's an improved and approved --

(Laughter.)

MR. CLIFFORD: Four of the PWRs credit improved statistics within the Astram methodology, and seven PWRs had to rely on multiple credits. All of the calculations were performed and documented in accordance with the vendor's Appendix B QA program.

MEMBER ABDEL-KHALIK: Do these calculations take into account the change in thermal conductivity that was discussed this morning?

MR. CLIFFORD: Not all of them.

MEMBER ABDEL-KHALIK: So how would that affect your assessment of where we are?

MR. CLIFFORD: I will get to that.

MEMBER ABDEL-KHALIK: All right, good.

MR. CLIFFORD: With respect to breakaway oxidation, as I mentioned, only one plant exceeded

2,000 seconds. So the remaining 103 plants would easily show that they were below the measured breakaway time. but the last plant was -- while it was a little closer to the breakaway time, remained below.

The staff conducted an audit of all of the supporting fuel vendor calculations, to confirm that the revised analytical limits were in accordance with the research findings, and that alloy-specific corrosion models and hydrogen uptake models were used and that were accurate and supported by data.

We evaluated the quantification, justification, and application of the analytical credits, reviewed a sampling of the new LOCA calculations, and identified any changes to the existing approved methods and models. And as a result of the audits, we compiled plant-specific data and evaluated each individual's plant with respect to the revised limit. And we generated a -- what we call an ECCS margin database, which provides the specific data for each and every plant.

There it is -- ECCS margin database. I believe this was made available to the Subcommittee. I'm not sure any members of the full Committee have seen it.

MEMBER SHACK: I didn't realize that was put together by you rather than industry, but --

MR. CLIFFORD: It was put together by me, yes.

MR. CLEFTON: We had trouble putting all of the industry into one piece of paper because of the proprietary information. Paul is a central point of the separation between General Electric/Westinghouse. We had cooperation, certainly, with each of their representatives, but there was some information that Paul saw uniquely with all three that individually didn't show.

CHAIR ARMIJO: We've been treating that as proprietary, but at some point it is non-proprietary.

MR. CLEFTON: We are working right now to clarify a document that will have all of the proprietary information removed, but --

MR. CLIFFORD: I would imagine we would maintain two databases, one non-prop, one prop.

CHAIR ARMIJO: Yes, okay.

MR. CLEFTON: It turns out there is very few words in there that are of concern. One was a table that was directly copied, and it had a proprietary statement on the bottom. That is back to the lawyers, one of the vendors right now. And when they process it and give us the paperwork, then we will be able to coordinate and get a fresh, sanitized issue that can go out.

MR. CLIFFORD: Okay. For the existing commercial fleet, the performance safety assessment confirms and documents on a plant-specific basis that each and every plant continues to operate in a safe manner.

We also evaluated the future operation of Watts Bar Unit 2 and Bellefonte's Units 1 and 2 with respect to the research data and found that they would have margin. In addition, the newer plants are also using newer alloys, which are less susceptible to hydrogen uptake.

But, yes, in general, the direction of the fleet is in a beneficial direction, because the older alloys are being retired, being replaced with new, modern alloys, which absorb less hydrogen. Like, for instance, I believe there is only four plants that are currently being loaded with zirc-4, and it's my understanding that they all have expectations to migrate to advanced cladding.

For the certified reactor designs, the advanced reactor designs include enhanced ECCS performance characteristics. As we described earlier, the ESBWR, because of the system design, has no core uncovery. The remaining certified designs have significant margin.

MEMBER ABDEL-KHALIK: I guess I didn't hear, you know, your promise response as far as this ECCS margin database as to the effective --

MR. CLIFFORD: That's on the next slide.

MEMBER ABDEL-KHALIK: Okay.

MR. CLIFFORD: I think. I deleted a bunch of slides. Let me just --

CHAIR ARMIJO: Well, you must have, because it's not on the next slide.

MR. CLIFFORD: Okay. Yes, I deleted some slides from the -- but I will talk to it.

Right. The thermal conductivity degradation would impact the stored energy, which would impact the calculated PCT and ECR. Obviously, the PCT hasn't changed. They are still meeting the 2,000. The question is: does the evaluation that includes the effects of thermal conductivity affect the margin that is generated in the database?

As the slide that I deleted, unfortunately, talks about how we are going to maintain the database, and that it will be updated on an annual basis, as new license amendment requests come in, we will be asking them to confirm any changes on -- like if they do a power uprate. How does a power uprate affect the documented margin in the database?

So we are going to be maintaining that margin. I was at an audit last week for a fuel transition, and we brought up that point and they provided us with the data showing that, well, ECR increased slightly with the fuel transition. It is still such that they needed no credits. So they still were in the same category they were before. They needed no credits to meet the revised -- the expected ECR based on the research data.

MEMBER SHACK: But you don't have enough results to go off and apply an adjustment the way that they used an adjustment, you know, to take credit for some things.

MR. CLIFFORD: No.

MEMBER SHACK: I mean, this would be a negative adjustment.

MR. CLIFFORD: Correct. Right now they are doing plant-specific assessments. So as soon as they make the assessment they will issue a 30-day notice under existing 50.46 reporting requirements. And when we receive those, we will then go back to each of the vendors -- each of the licensees -- sorry -- and ask them, how does this affect the margin that we are currently crediting to show that you are safe in the interim until we implement the new rule?

So we will be actively going to each of the licensees when they submit that 30-day report and following up on how the changes impact the database. And we're already doing that. We're doing it with Turkey Point now. We're doing it with Dominion in their fuel transition. So we are already doing it.

CHAIR ARMIJO: Okay, Paul.

MR. CLIFFORD: Okay. So the research findings necessitate new ECCS requirements. The majority of plants needed no new calculations or adjustments to show positive margin. The database will be maintained and confirmed until such a point as the new requirements are implemented.

CHAIR ARMIJO: Okay. Thank you. Implementation.

MR. CLIFFORD: This is very short, so -- okay. Here is the agenda. There is a tremendous amount of work scope that is necessary to implement the new requirements. This slide tries to capture, at least in general terms, what the major tasks are, milestones are, in order to implement.

In blue I have highlighted what I feel is the most labor intensive part, and that would be to perform plant-specific LOCA analyses, to prepare license amendment requests, and for the staff to review 80-plus license amendment requests. I say 80 because some of the plants are multiple sites, so it is not 104. It is generally somewhere less; it is around 80.

Based upon the ANPR comments, we identified workforce limitations to complete parallel analysis. A staged implementation plan would be the most effective and efficient way to implement the new requirements of 50.46(c).

Our original attack -- or our original approach to this strategy was that plants with the least amount of safety margin would be required to be in compliance at the earliest time. It's illustrated here.

However, recognizing that plants with the least amount of margin are likely to require the most effort and the most calendar time to document compliance, in that there is a substantial number of plants that do not require new LOCA models, methods, or analyses, we revised our staged implementation strategy to move the 60-plus plants that are in track three up to the beginning of the calendar in parallel.

CHAIR ARMIJO: They are actually going on in parallel, wouldn't they?

MR. CLIFFORD: Hmm?

CHAIR ARMIJO: These activities with track one and two and three, wouldn't they basically be going on in parallel?

MR. CLIFFORD: No.

VICE CHAIR STETKAR: In the industry, but not --

CHAIR ARMIJO: In industry. The industry guys would be preparing this up in parallel, but the staff can't do it all at --

VICE CHAIR STETKAR: Correct.

MR. CLIFFORD: And the industry can't do it all at the same time either. I'm sure Gordon can attest that you just can't run 80 LOCA analyses at the same time.

MR. CLEFTON: We get a choke point with resources, no question about that. The benefit of this -- bringing the majority in that have minimum credits to apply is the fact that lessons learned of doing the applications and submitting it will be shared among the vendors and hopefully through NEI to make those with least margin aware of some of the choices and options that are available for them.

So the lessons learned of the majority going through first will help the folks that are, as you identified, the most intense in response to the new rule.

CHAIR ARMIJO: Okay.

MR. CLEFTON: So we are supportive of getting a majority of minimum action people through the process.

MEMBER ABDEL-KHALIK: "Help them" in what sense? Sharpen their pencils or --

MR. CLEFTON: Well, look at the different credits that are available. The plants that have -- we have all maintained the peak centerline temperature values. We haven't looked at margin as such as a regulatory requirement. We have a limit that we may not exceed. So we have adjusted with variables and credits associated with attaining the expected performance at each plant.

And some of the plants have never touched that or changed it since their original licensing. And now with the -- a new regulation they may be challenged to come up with a wider margin or a different margin. So by sharing what other vendors and other plants are using for credits, if you will, to make adjustments to their margin assessment calculations, those with a small amount may be able to get more accurate calculations on their own site.

MEMBER SHACK: Well, I guess, I mean, also, it's not clear -- when we say "margin" here, we are talking about sort of computational margin, aren't we?

MR. CLEFTON: That's correct.

MEMBER SHACK: The guy with the -- nothing but Appendix K calcs looks bad, but in fact he is going to -- he has probably got the biggest real margin in the world. He just doesn't know it.

MR. CLIFFORD: Right. And we took that into account when developing --

MEMBER SHACK: Did you try to do that?

MR. CLIFFORD: We did.

MEMBER SHACK: Because that's --

MR. CLIFFORD: And I'll explain that.

MEMBER SHACK: So you really think this is true -- or this is your best estimate of true margin.

MR. CLIFFORD: I mean, we feel that the plants with the least available margin are the ones that are already using an Astram or a realistic model --

MEMBER SHACK: Okay.

MR. CLIFFORD: -- but still needed to take some credits to meet the data, whereas if we move the Appendix K plants down to track -- well, they are actually track two now in this spot. We moved them behind it because they have inherent margin in their calculational methodology. So we took that into account.

Okay. The implementation plan was designed to achieve the following objective: to expedite the implementation to as many plants as soon as possible, to prioritize implementation on plants with less inherent safety margin, and to balance the workload.

This table kind of explains the logic. Track one, which would be -- required to be in demonstration within 24 months of the effective date of the rule would be the plants -- let's see, this is -- a lot of BWRs and PWRs here, which do not require new analyses or new -- or model revisions.

The next grouping of plants which we required are the plants with really the least amount of margin, and those are the realistic LOCA models that require new analyses. And there is 16 plants there.

The third are the plants using -- oh, I'm sorry, Item 2 is also the BWR-2s, which have less inherent margin relative to the rest of the BWRs.

CHAIR ARMIJO: So that's two of those guys.

MR. CLIFFORD: Two of those.

CHAIR ARMIJO: Okay.

MR. CLIFFORD: And the third track would be the PWRs using Appendix K and requiring new methods. And they may require the most amount of work, because most of those plants currently don't have a realistic model. Most of the -- I don't believe there is a realistic model of proof of the CE fleet, so -- as an example.

And we grouped the BWR-3s in this category, really to balance the workload. And even though you see 16 plants in two and 23 plants in three, it turns out to be the exact same number of analyses of record due to multiple unit sites.

In the rule, there is a listing of plants that you can -- you all have the rule language.

CHAIR ARMIJO: Yes.

MR. CLIFFORD: So if you look at the rule language, there is a table that shows where the plants fall, and in here it's Table 1. So if you wanted to see how they fall here.

Paragraph O, which is the implementation, which is the rule language which dictates -- I'm not going to go into each of the paragraphs, but essentially this paragraph required many subparagraphs because there is a lot of perturbations on where plants were licensed, when they were licensed, and where the rule falls.

In other words, if you are an existing Part 50 plant, there has to be the legal definition of when you have to be in compliance. If you are a Part 50 construction permit, or you're a Part 52 certified design, or if you're a Part 52 COL, there's a lot of different types of plants and types of circumstances which needed to be put into the rule.

MEMBER ABDEL-KHALIK: If you go back to the previous slide, the difference between 24 months and 48 months, that increment between each group is dictated by what?

MR. CLIFFORD: It's informed by the amount of time it takes to do the analysis.

MEMBER ABDEL-KHALIK: Not the amount of time it will take you to do the reviews.

MR. CLIFFORD: No. This is the date that they would have to submit the analysis to the NRC, not the date that the NRC would have to find it acceptable, because that would put a tremendous burden on us to maintain the schedule.

MEMBER ABDEL-KHALIK: And that's bad.

(Laughter.)

MR. CLIFFORD: Well, it would put a burden on the licensee, because it would be on their -- it would be beyond their control. They would submit it. And if it took us longer, they are in violation of the rule, because we didn't get it done. That doesn't make -- to me, that doesn't make sense.

MEMBER ABDEL-KHALIK: But if you look at the first grouping, for example, what would be involved on your part to do these reviews?

MR. CLIFFORD: Well, I'm glad you brought that up, because I forgot to mention it. What we are trying to do in grouping one is to define a regulatory process whereby the plants would update their FSAR. These are for plants that don't need to redo their analysis.

So basically they would update their FSAR saying, "I am now in compliance with 50.46(c)," and then they would send us a report. They would send us the annual report saying, "I am now in compliance. Here is my analysis of record. I meet the new requirements. Done." And we wouldn't review each of those license amendment requests.

CHAIR ARMIJO: Do those people have to do anything else internally? Changing tech specs or internal documentation or anything other than send me this letter saying, "We have updated the FSAR and we are in compliance"?

MR. CLIFFORD: There is a potential, because they -- each of the vendors is probably going to need to submit a topical report before this process really begins, and identify their hydrogen uptake model for each of their alloys, and then they would define using the reg guide allowable ECR versus hydrogen, they would convert that to probably allowable ECR versus burnup for their given alloy.

And so that would be an approved topical report. The question is: does that topical report then have to be put into the tech specs of each plant? And if that was required, then each plant would have to submit a license amendment request.

So we are trying to avoid that, because we want to get these 65 plants into compliance as soon as we can.

MEMBER BROWN: How does the numbers of these plants relate to this LOCA record thing, where you've got a number, those four bars and -- the first bar is in implementation track one? That is 512.

MR. CLIFFORD: That's a different job.

MEMBER BROWN: It's a performance safety assessment.

MR. CLIFFORD: It's not directly related, because, for instance, if they were using M5, they would be allowed 17 percent ECR, because M5 doesn't absorb hydrogen. So even if they were calculating 16 percent, they would still be in conformance. So even though they're on the far right side of that plot, they still would needn't a reanalysis. they wouldn't need to do anything.

MEMBER BROWN: Because they have a longer time is irrelevant, or they've got better performance requirement -- the 17 percent.

MEMBER SHACK: It's really -- the one that controls is the previous bar graph, you know, this bar graph.

MEMBER BROWN: Okay.

MR. CLIFFORD: Is that the ECR one?

MEMBER BROWN: Yes.

MR. CLIFFORD: Okay.

MEMBER BROWN: All right. I was just trying to connect the dots between them.

MEMBER SHACK: For most of the guys, the

breakaway is not going to be a problem for them.
MR. CLIFFORD: Right. There is only one plant that that is even --
MEMBER SHACK: Right.
MEMBER BROWN: But your other slides show that the fuel -- I'm not a fuel guy, so that's why I'm asking. So all of them are 3,500 seconds and greater. You had another slide where you went through all of the four fuel types.
MR. CLIFFORD: Right.
MEMBER BROWN: Wherever that one is. So that it seems like all of these fell well within --
MR. CLIFFORD: Except for that one plant, that's correct.
MEMBER BROWN: Well, that's just greater than 3,500 or -- is it greater than 5,000? Is it cleanup?
MR. CLIFFORD: That is documented in the margins, the proprietary margins.
MEMBER BROWN: Okay. All right.
MR. CLIFFORD: You can look at that plant and you will see how much margin they have. It's a good point, though, because we're talking that maybe these tests aren't necessary. But that plant is within a couple hundred seconds of its breakaway, so

maybe there is a small manufacturing change that causes it to go from 5,000 to 4,500, and now it is no longer acceptable.

CHAIR ARMIJO: Well, that guy has got a problem. But you don't punish the whole class because one kid misbehaves, so --

(Laughter.)

MR. CLIFFORD: Well, during the Subcommittee we talked about this implementation flowchart. I don't know if -- it is tough to read now, and I --

(Laughter.)

CHAIR ARMIJO: Yes, we looked at it, and we were going to spend a lot of time --

MEMBER SHACK: At the Subcommittee we had a big page.

VICE CHAIR STETKAR: This is a big page.

MEMBER SHACK: It was even bigger.

MR. CLIFFORD: The purpose is just to understand the calendar time it takes to implement it. And while there are some things in parallel, there are also other activities that will be in series, and just to illustrate, really, the timeframe.

CHAIR ARMIJO: Okay. Yes, I don't think we need to go into the details of this, how you are going to pull it off. So we can -- unless you have something else --

MR. CLIFFORD: That's all I have.

CHAIR ARMIJO: You're done?

MR. CLIFFORD: I'm done.

CHAIR ARMIJO: All right. Well, I would like to get some feedback from the members, and I'll start with Jack.

MEMBER SIEBER: I have no additional comment.

CHAIR ARMIJO: Dr. Banerjee, nothing?

MEMBER BANERJEE: No.

CHAIR ARMIJO: Steve?

MEMBER SCHULTZ: I would be interested in NEI's comments related to the obligations of the licensee with regard to what is in the now-current rule, proposed rule, regarding the testing.

MR. CLEFTON: We're in a situation that we saw the statement of considerations about, what, a week and a half ago for the first time. And it has been distributed to our focus group but not to the mass distribution of the entire fleet of plants.

So what we are looking forward to now is a release of the official document, because this one, as you can tell, has "draft" written all over it, and we may have some modifications that go out. Our feeling is with stakeholder meetings, public workshops, and stuff, we will refine our comments, so we don't really have any right now other than premature and what we have looked at through the APN process -- ANPR process and this draft that we have.

So we will have a number of comments. There is a lot of coffee cup conversations about the duration of the review period, about the implementation schedule, why we are selecting some or just make it one date for the whole fleet. So those types of comments will come out later on, but I think it is premature right now to get a consensus statement from the industry.

So I will have to buy off that we will get that to you with the comment period -- or get to the staff with the comment period that will follow within, what, a month or two after the EDO finishes with.

We have Commission vote time, too, so we may not even get a comment period that isn't until later in 2012. I'm not sure that answers your question, but we have some interest in that, certainly.

(Laughter.)

MEMBER SCHULTZ: And my other concern

would be, as I think has been discussed quite thoroughly, the issues that Sam brought up with regard to the testing requirements. If anything is going to be implemented, more direct guidance ought to be provided, and it ought to be informed by examining the fabrication process and the relationship between the licensee and the fuel vendor, and all of the testing and programmatic requirements that are already in place.

CHAIR ARMIJO: Okay. Steve, is that it?

MEMBER SCHULTZ: Yes.

CHAIR ARMIJO: Dick?

MEMBER SKILLMAN: Yes, two issues. For the three different implementation tracks, is it accurate that the starting time for the licensees will be the same point in time?

MR. CLIFFORD: I don't believe that is possible, just due to the limitations in the qualified technical staff at the fuel vendors. There's three vendors. There are a limited amount of people that can run these LOCA analyses. So there is no way they could run them all in parallel.

MEMBER SKILLMAN: So the requests to the utilities will be at different times or at the same time?

MR. CLIFFORD: No, no. When the rule is issued --

VICE CHAIR STETKAR: That starts the time clock.

MEMBER SKILLMAN: I believe that was the answer. That's what I was looking for.

MR. CLIFFORD: Okay.

MEMBER SKILLMAN: Second question, to what extent -- you mentioned that you have met with the fuel vendors. To what extent will this request be a surprise to the licensees? Do they know this is coming?

MR. CLIFFORD: We have had, I would say, more than the usual amount of public interaction on this.

MR. CLEFTON: This is Gordon Clefton from NEI. With the ANPR process, the draft proposed rule with the 12 parts all provided to the industry, we had workshops that had 75, 80, 90 people into rooms.

So the utilities were invited, and many participated heavily. With the three vendors, we had their participation as a supplement, because there was significant interest from the utilities and the different sites, so we have had good involvement. They recognize that we have hit a plateau in development here since, what was that, 2009 when we had most of those workshops? And they are waiting for a comment period that will come out.

MR. CLIFFORD: And we have presented material at an ANS conference --

MEMBER SKILLMAN: Okay.

MR. CLIFFORD: -- discussing the probability of a new rule coming.

MR. CLEFTON: And at the RIC, too, right?

MR. CLIFFORD: And at the RIC.

MR. CLEFTON: So we had the RIC presentation not this year but the year before and had good participation there. So it has not been shaded from the utilities at all. We have had good participation.

MEMBER SKILLMAN: Thank you.

MR. CLEFTON: It should be no surprise.

MEMBER SKILLMAN: Thank you.

CHAIR ARMIJO: Dr. Powers.

MEMBER POWERS: Well, I would certainly be interested in seeing what the public comments are on this batch testing. E-110 scared the hell out of us because of the sensitivity. On the other hand, this is the sort of thing that gets scrubbed out when you do a design of a process facility. And so it may be a concern that we need to revisit in drafting the final rule language.

It is apparent to me -- I mean, I am delighted that we are finally getting this research finding out into the rule language, and trying to get the rules so that they are less alloy-dependent, because I think there are new alloys coming down.

One of the things that I guess I am concerned about is, as we develop new alloys, we are going to start wringing out more and more benefit, and other things that have not been a concern to us in the past are going to come up and surprise us. And one of the areas that I am particularly interested in is absorption of ions and species onto cladding that in the past has not been important, but as we refine these alloys may suddenly emerge as important.

So I think there is going to be room for continued clad research in the future in this area.

Those are the only comments that I want to make.

CHAIR ARMIJO: Okay. Thank you, Dana. Harold?

MEMBER RAY: Nothing, thank you.

CHAIR ARMIJO: Okay. John.

VICE CHAIR STETKAR: Nothing. Thanks.

MEMBER RYAN: No additional comments. Thank you.

CHAIR ARMIJO: Mike.

MEMBER CORRADINI: No additional comments.

CHAIR ARMIJO: Dr. Shack.

MEMBER SHACK: No.

MEMBER BROWN: Just a question. 50.46(a) doesn't get better voted on? Are these two things interrelated, or can they be done separately?

CHAIR ARMIJO: Well, they're separate, but they --

MEMBER BROWN: Well, they talked about you needed conforming or something before --

CHAIR ARMIJO: Well, if 50.46(a) never gets voted on, this still applies to everybody. And it's just --

MEMBER BROWN: It's seems like it would. I'm just asking --

CHAIR ARMIJO: It's just a benefit that the AWR guys would never be able to take advantage of. That's --

MR. LANDRY: This is Ralph Landry. If 50.46(a) was never voted out by the Commission, then there is nothing to conform it. We would just -- it won't affect this rule. The only rule that would be affected would be if 50.46(a) was voted out and approved, then there would be some action taken to require 50.46(c), but that was voted out in --

CHAIR ARMIJO: Yes.

MR. LANDRY: -- 46(a) would not affect 46(c).

CHAIR ARMIJO: Right. Well, it gets back to me. I have said a lot of things, but what I haven't said is the fact that this has been a really superb piece of research and analysis and planning and excellent cooperation between industry and the staff.

And I think it is moving forward. I think this rule has the potential to really be a landmark improvement where science, physics, chemistry, reality, is in the regulations. And, you know, I think you are going to get a lot of comments. You are certainly going to get some from me, but -- and you have already gotten them.

But I think the additional goal I would kind of urge the staff to think about is not only is it a good rule from a technical and safety point of which, is sort of top priority, but also should be viewed from a standpoint of practicality, reasonableness, a burden on the staff, and on licensees to minimize anything that isn't really --

directly affects safety.

But with that, I would like to, again, thank the presenters, a terrific presentation. Took longer than we expected, but I --

MEMBER SHACK: You had an indulgent chairman.

(Laughter.)

CHAIR ARMIJO: You had an indulgent chairman, and our members have been very patient for lunch.

And so with that, thank you very much. And it is 1:00. I think we are going to -- we have one letter to write this next day and a half, so I think we can just reconvene at -- we'll take an hour for lunch -- 2:00.

(Whereupon, at 1:00 p.m., the proceedings in the foregoing matter went off the record.)

U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

590th Meeting of the Advisory Committee on Reactor Safeguards

Turkey Point Units 3 and 4 Extended Power Uprate

January 19, 2012

Introduction

Allen G. Howe

Deputy Division Director

Division of Operating Reactor Licensing

Office of Nuclear Reactor Regulation

Jason C. Paige

Project Manager

Division of Operating Reactor Licensing

Office of Nuclear Reactor Regulation

EPU Overview

- Background
  - ❖ TP EPU Application – October 21, 2010
  - ❖ 2300 to 2644 MWt, 15 % increase (344 MWt)
    - Includes a 13 % power uprate and a 1.7 % MUR
    - 20 % increase above original licensed thermal power
- EPU Review Schedule
  - ❖ Followed RS-001
  - ❖ Linked licensing actions
    - AST – approved June 23, 2011
    - SFP Criticality analysis – approved October 31, 2011
  - ❖ Supplemental responses to NRC staff RAIs and Audits

Agenda

- EPU Overview
- Plant Modifications
- Safety Analysis Overview
- Mechanical and Civil Engineering

Turkey Point Units 3 and 4 Extended Power Uprate

Safety Analysis

Benjamin Parks
Reactor Systems Branch

Subcommittee Recapitulation

- Review Focus Areas
  - ❖ Main Steam Line Break
  - ❖ Emergency Core Cooling System Evaluation
  - ❖ Safety-significant events outside TP licensing basis:
    - -Feedwater Line Break
    - -Inadvertent Opening of Primary Relief Valve
    - -Modes 4/5 Boron Dilution

Subcommittee Recap, continued

- Significant review results:
  - ❖Licensee increased shutdown margin requirements for boron dilution events
  - ❖Licensee demonstrated operator capability to mitigate inadvertent PORV event
  - ❖Licensee provided analytic improvements to post-LOCA boron precipitation analysis

Subcommittee Open Items

- Thermal-Conductivity Degradation (TCD)
  - ❖NRC published IN 2011-21, "Realistic Emergency Core Cooling System Evaluation Model Effects Resulting from Nuclear Fuel Thermal Conductivity Degradation," during staff review of EPU
  - ❖Licensee is revising steady-state fuel performance calculations and realistic ECCS evaluation to incorporate TCD effects

S/C Open Items

- RCS Overpressurization
  - ❖Conservative analysis input assumptions deliver a conservatively high peak pressure
- SFP Criticality Analysis
  - ❖Staff review of a new, parenthetical statement in TS is ongoing

Open Item Resolution

- Licensee has provided supplements describing TCD analyses
  - ❖Steady-state fuel performance calculations
  - ❖Transient/Accident analysis impacts
  - ❖Realistic ECCS evaluation model changes

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Staff Review of Open Items

- Perform confirmatory fuel performance calculations using FRAPCON
- Assess realistic ECCS evaluation model changes
- Review licensee evaluation of remaining accident/transient analyses
- Issue supplemental safety evaluation
- Brief ACRS on results at later meeting

Conclusion

- Staff finds EPU safety analysis generally acceptable
- Staff continuing review of TCD assessment

Turkey Point Units 3 and 4
Extended Power Uprate
ACRS Full committee Meeting

Mechanical & Civil Engineering Review

Chakrapani Basavaraju, Ph.D.
Martin Murphy (EMCB Chief)
Mechanical & Civil Engineering Branch
Division of Engineering
Office of Nuclear Reactor Regulation

Review Scope

- NRC staff reviewed the impact of the EPU on the structural integrity of the SSCs
- Piping systems that are mainly affected by the EPU include the following:
  - ❖ Main Steam, Condensate, Feedwater, Extraction Steam and Heater Drains.
  - ❖ These systems required piping and pipe support modifications and/or equipment replacement /modification/addition to accommodate EPU conditions.
- Structural evaluations of SSCs (including proposed modifications) at EPU conditions employed current plant design basis methodology and acceptance criteria
- Structural evaluations met design basis code allowable values

OPEN ITEMS from ACRS Subcommittee Meeting

- SFP supplemental heat exchanger license condition wording
- 6th Feed water Heater Discharge Nozzle Terminal End Break (TEB) Zone of Influence

License Condition related to SFP Supplemental Heat Exchanger

- To maintain current design limits at EPU conditions, a supplemental Heat exchanger will be added to the cooling loop of spent fuel pool for each unit
- The NRC staff's review of the EPU LAR identified that the structural design and analysis of spent fuel pool supplemental heat exchanger (SFP suppl HX) associated modifications at EPU conditions had not been completed
- Therefore, the staff has imposed the following license condition

SFP Suppl. HX License Condition

- **License Condition**

  Prior to completion of the Cycle 26 refueling outage for Unit 3 and cycle 27 refueling outage for Unit 4, the licensee shall confirm to the NRC staff that the design, structural integrity evaluations, and installation associated with the modifications related to the SFP suppl. HXs are complete, and that the results demonstrate compliance with appropriate FSAR and code requirements. As part of the confirmation, the licensee shall provide a summary of the structural qualification results of the piping, pipe supports, supplemental heat exchanger supports, and the inter-tie connection with the existing heat exchanger for the appropriate load combinations along with the margins.

HELB Methodology Overview

- Current Turkey Point licensing basis requirements related to HELB are based on the Giambusso AEC Letter criteria (1972) for systems outside Containment & remain the same for EPU.

- The licensee is continuing the same HELB methodology for EPU that was previously used by the licensee for the CLB prior to EPU, as well as for license renewal.

- Acceptance criteria based on compliance with Turkey Point General Design Criterion (GDC) 40.

Replacement of Sixth FW Heater & Nozzle Modification in support of the EPU

- **Only HELB analysis outside containment affected by EPU is the main feedwater system because the number 6 feedwater heater discharge nozzle size increased from 18 inches to 24 inches nominal diameter**
- In accordance with the HELB criteria, the licensee postulated terminal end breaks at the discharge nozzles of the replaced sixth FW heaters

Replacement of Sixth FW Heater & Nozzle Modification in support of the EPU (cont'd)

- The licensee performed walkdowns and identified equipment important to safety
- **The licensee made a conservative decision to install deflector shields on the discharge nozzles and not to use any zone of influence criteria for EPU HELB analysis.**
- These shields are designed to redirect jet forces and guide streams in a direction away from the safety-related equipment
- The staff finds that the licensee has adequately addressed and evaluated the terminal end break at the outlet nozzle of 6^{th} FW Heater

Conclusions

Based on the review of the licensee’s evaluations, the staff concluded that reasonable assurance has been provided to ensure that plant systems, structures, and components important to safety are structurally adequate to perform their intended design functions under EPU conditions.

QUESTIONS

Public Comments

U.S.NRC
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Committee Guidance Comments

Adjourn

FPL

Turkey Point
Extended Power Uprate (EPU)
ACRS Full Committee

January 19, 2012

Agenda

- **Introduction .... Mike Kiley**
- EPU Overview and Plant Modifications.................................. Steve Hale
- Safety Analysis Overview.................. Carl O'Farrill
- Acronyms

FPL

Turkey Point

- Located 25 miles south of Miami, Florida
- Pressurized Water Reactor (PWR)
- Westinghouse 3 Loop Nuclear Steam Supply System (NSSS)
- Westinghouse Turbine Generator
- Architect Engineer – Bechtel Power, Inc.
- Each Unit output 795 MWe gross

FPL

Turkey Point

- Original operating licenses issued in 1972 for Unit 3 and 1973 for Unit 4
- Steam Generators (SGs) replaced in 1982 and 1983
- Two additional safety grade Emergency Diesel Generators installed in 1991
- Renewed Operating Licenses issued in 2002
- Reactor Vessel Heads replaced in 2004 and 2005

FPL

Turkey Point

- **Thermal Power**
  - Original Licensed Thermal Power 2200 MWt
  - Current Licensed Thermal Power 2300 MWt
    - -- Stretch Uprate 104.5% (1996)
  - EPU Thermal Power 2644 MWt
    - -- Implement 2012 - 2013

Agenda

- Introduction .... Mike Kiley
- **EPU Overview and Plant Modifications.................................. Steve Hale**
- Safety Analysis Overview.................. Carl O'Farrill
- Acronyms

FPL

FPL is requesting approval for a 15% power level increase for the Turkey Point units

- **15% increase in licensed core power level (2644 MWt)**
  - 13% Power Uprate
  - 1.7% Measurement Uncertainty Recapture
  - (2300 x 1.13) x 1.017 ~ 2644 MWt
- **Attributes of the Turkey Point EPU**
  - Classic NPSH requirements for ECCS pumps are met without credit for containment overpressure
  - No fuel design changes for EPU
  - License Amendment Request 196: Alternative Source Term (AST)
    - -- Radiological accident analyses performed at EPU conditions
    - -- License amendment issued in June 2011
  - License Amendment Request 207: Spent Fuel Pool Criticality
    - -- Analyses included EPU fuel conditions
    - -- License amendment issued in October 2011

FPL

FPL is requesting approval for a 15% power level increase for the Turkey Point units

- **Grid stability studies have been completed and approved for the EPU full power output**
- **Final required modifications to support EPU operation will be implemented in 2012 - 2013**
  - Spring 2012 outage for Unit 3
  - Fall 2012 outage for Unit 4

Analyses were performed to evaluate the changes in design parameters

Parameter	Original	1996 Uprate	EPU	EPU Change
Core Power (MWt)	2200	2300	2644	+344
RCS Pressure (psia)	2250	2250	2250	0
Taverage (°F)	574.2	571.2[(1)] – 577.2	570.0 – 581.5	-1.2 / +4.3
Vessel Inlet (°F)	546.2	540.4 – 546.6	535.5 – 549.2	-4.9 / +2.6
Vessel Outlet (°F)	602.3	602.0 – 607.8	604.5 – 616.8	+2.5 / +9.0
Delta T (°F)	56.1	61.6 – 61.2	69.0 – 67.6	+8.4 / +6.4
Thermal Design Flow (gpm/loop)	89,500	85,000	86,900	+1,900
Core Bypass (%)	4.5	6.0	6.3	+.3
Steam Pressure (psia)	785	701 - 832	701 - 822	0 / -10
Moisture Carryover (maximum, %)	0.25	0.25	0.25	0
Steam Mass Flow(10^6 lb/hr)	9.60	10.13 – 10.17	11.59 – 11.64	+1.46 / +1.47

(1) Some analyses consider T_{avg} of 566.2°F for an end of cycle coastdown

FPL

Modifications will be made in support of the Safety Analysis

- Nuclear Steam Supply System (NSSS) setpoints
- Pressurizer Level Program and Safety Valve Lift Settings
- Hot Leg Injection Flow Path
- Emergency Containment Coolers Auto Start Logic
- Main Steam Safety Valve Setpoint Changes
- Main Steam Isolation Valve (MSIV) and Main Steam Check Valve (MSCV) Upgrades
- Modify / Install Feedwater Isolation Valves
- Install Leading Edge Flow Measurement (LEFM) System
- Refurbish Auxiliary Feedwater Pumps
- Remove Auxiliary Feedwater Control Valve Travel Stops
- Safety Related Piping Support Modifications
- Jet Impingement Shields
- Technical Support Center Shielding Modifications
- Install Additional Spent Fuel Pool Cooling Capacity

FPL

Modifications will be made in support of power generation at the EPU power level

- **Steam Path**
  - Replace High Pressure Turbine
  - Electro Hydraulic Control (EHC) System and Control Valves
  - Digital Turbine Controls
  - Replace Moisture Separator Reheaters (MSRs)
- **Condensate and Feedwater**
  - Replace Main Condensers and Condenser Cleaning System
  - Replace Condensate Pumps and Motors
  - Replace Feedwater Pump Rotating Assemblies
  - Modify Main and Bypass Feedwater Control Valves / Actuators
  - Replace High Pressure Feedwater Heaters
  - Replace Gland Steam Condenser and Piping
  - Steam Jet Air Ejector Tube Bundle Replacement

- Continued on next page -

FPL

Modifications will be made in support of power generation at the EPU power level (continued)

- **Heater Drains**
  - Modify Heater Drain Piping
  - Heater Drain System Control Valve and Digital Upgrade
- **Other Balance of Plant items**
  - Balance of Plant (BOP) Setpoints
  - BOP Piping Supports
- **Auxiliary Support Systems**
  - Replace Turbine Plant Cooling Water Heat Exchangers
  - Replace Control Rod Drive Mechanism Fan Motors and Coolers

- Continued on next page -

Modifications will be made in support of power generation at the EPU power level (continued)

- **Electrical Modifications**
  - Generator upgrades including
    - -- Stator rewind
    - -- Rotor replacement
    - -- New current transformers
    - -- New Hydrogen coolers
    - -- New exciter air coolers
  - Iso-Phase Bus Duct Modifications
  - Main Step-up Transformer Cooling and Tap Changer Modifications
  - Replace Unit Auxiliary Transformers
  - Switchyard Modifications

FPL

Open items from the draft EPU Safety Evaluation (SE) and ACRS sub-committee meeting addressed

- **Open items resolved (refer to Staff presentation)**
  - Updated Spent Fuel Pool heat exchanger license condition
  - HELB - High Energy Line shield being utilized
  - Loss of Load Analysis conservatisms confirmed
- **Two open items from draft SE under Staff review**
  - New fuel storage area criticality analysis use of alternate burnable absorbers
    - -- FPL issued response describing analysis process to be followed under 10 CFR 50.59
      - Technical Specification wording permits the implementation of alternative burnable absorbers to effectively control power peaking within the reactor core
  - Large Break LOCA analysis addressing nuclear fuel thermal conductivity degradation—discussed in next section

FPL

Agenda

- Introduction .... Mike Kiley
- EPU Overview and Plant Modifications.................................. Steve Hale
- **Safety Analysis Overview.................. Carl O'Farrill**
- Acronyms

FPL

Safety analyses are conservative and improved

- **Key changes beneficial to safety analysis**
  - Improved methods
  - Reduction of peaking factors (Heat Flux Hot Channel Factor (Fq) and Hot Channel Enthalpy Rise Factor ($F_{\Delta H}$))
  - Reduction in axial offset operating limits
- **Conservative inputs/assumptions**
  - Conservative physics parameters
  - Bounding plant operating parameters
  - Conservative trip setpoints
- **Conservative analysis DNBR limit**
  - Safety Analysis Limit (SAL) for DNBR is set conservatively to maintain margin to the DNBR design limit

FPL

Conservative analysis methods applied for non-LOCA events with all results meeting acceptance criteria (continued)

	Event	Criteria	Result
Decrease (Loss) in RCS Flow (Reduced Primary Cooling)	Loss of Flow (Cond III) 1) WRB-1 DNB Correlation 2) ABB-NV DNB Correlation non-mixing vane grid spans	DNBR (SAL*) **Upgrade Fuel** ≥1.40/1.40 (typical/thimble) **DRFA Fuel** ≥1.50/1.50 (typical/thimble)	 1.698/1.712 1.743/1.710
	Locked Rotor (Cond IV)	RCS Pres ≤ 2748.5 psia Rods-in-DNB ≤ 15%	2694.1 psia 0%
Overheating (Reduced Secondary Cooling)	Loss of Load (Cond II)	RCS Pres ≤ 2748.5 psia MSS Pres ≤ 1208.5 psia	2746.6 psia 1197.1 psia
	Loss of Feedwater (Cond II)	Przr Mix Vol ≤ 1300 ft^3	1198.5 ft^3
	Loss of AC Power (Cond II)	Przr Mix Vol ≤ 1300 ft^3	1185.9 ft^3
	ATWS	RCS Pres ≤ 3215 psia	3174.5 psia

* Safety analysis limit DNBR has margin compared to the DNBR design limit

FPL

Conservative analysis methods applied for non-LOCA events with all results meeting acceptance criteria (continued)

	Event	Criteria	Result
Overcooling	HFP MSLB (Cond III or IV)	DNBR (SAL*) **Upgrade Fuel** ≥1.40	1.836
		DRFA Fuel ≥1.50	2.117
		LHR ≤ 22.72 kW/ft	22.68 kW/ft
	HZP MSLB (Cond IV) WLOP DNB Correlation	DNBR (Correlation Limit) **Upgrade Fuel** ≥1.18 (typical/thimble)	1.464/1.411
		DRFA Fuel ≥1.18 (typical/thimble)	1.382/1.328
		LHR ≤ 22.72 kW/ft	22.198 kW/ft

* Safety analysis limit DNBR has margin compared to the DNBR design limit

FPL

Conservative analysis methods applied for non-LOCA events with all results meeting acceptance criteria (continued)

	Event	Criteria	Result
Reactivity Addition	Rod Withdrawal @ Power (Cond II)	DNBR (SAL*) ≥ 1.40 RCS Pres ≤ 2748.5 psia	1.48 2740.92 psia
	Rod Ejection (Cond IV)**	Fuel Enthalpy ≤ 200 cal/g Fuel Melt (at hot spot) ≤ 10%	178.33 cal/g 8.44%

*Safety analysis limit DNBR has margin compared to the DNBR design limit
**Includes effect of Thermal Conductivity Degradation (TCD)

FPL

Small Break LOCA safety margin is assured by key changes

Parameter	Pre - EPU	EPU
Analyzed Core Power (MWt)	2300	2644
Hot Channel Enthalpy Rise Factor [$F_{\Delta H}$]	1.70	1.65
Axial Offset (%)	20	13
Steam Generator Tube Plugging Level (%)	20	10
HHSI	One HHSI Pump	Two HHSI Pumps

FPL

Small break LOCA analysis performed using NRC-approved NOTRUMP evaluation model demonstrated acceptable results

	Pre - EPU	EPU	Limit
Limiting Break Size	3-Inch	4-Inch	-
PCT (°F)	1688	1231	2200
Maximum Transient Local Oxidation (%)	2.02	0.07	17.0
Maximum Core-Wide Oxidation (%)	< 1.0	< 1.0	1.0

Large Break LOCA Analysis Performed Using NRC Approved Best Estimate ASTRUM with results meeting acceptance criteria*

10 CFR 50.46 Requirement	Pre-ASTRUM/EPU Value	EPU Value	Acceptance Criteria
95/95 Peak Cladding Temperature (°F)	2040	2152	< 2200
50th Percentile Peak Cladding Temperature (°F)	1612	1633	-----
95/95 Maximum Local Oxidation (%)	11	10.5	< 17.0
95/95 Core Wide Oxidation (%)	0.70	0.40	< 1.0
Coolable Geometry	Long term cooling is maintained via operator actions. No impact on coolable geometry.		
Long-Term Cooling			

* Includes effect of Thermal Conductivity Degradation (TCD)

FPL

The effects of fuel pellet thermal conductivity degradation (TCD) has been assessed

- Data from experiments conducted at the Halden test facility in the 1990's indicated that TCD at higher burnups may not be sufficiently accounted for in industry nuclear fuel analysis codes
- Information Notice 2009-23, Nuclear Fuel Thermal Conductivity Degradation, indicated codes approved by NRC before 1999 may not adequately address this effect
- Previous assessments indicated sufficient conservatism existed within the current Westinghouse fuel performance methods to compensate for the TCD effect
- Westinghouse is developing an upgraded version of the PAD code which will explicitly account for TCD to be submitted in 2013 to NRC for approval

FPL

The effects of fuel pellet thermal conductivity degradation (TCD) has been assessed

- **Recent conservative estimates indicate that the impact of TCD on fuel average temperatures may be higher**
  - Assessments continue to indicate that the fuel average temperature at higher burnup remains below the fuel average temperature at zero burnup
- **NRC Staff issued Information Notice 2011-21, Realistic Effects of ECCS EM Effects Resulting from Nuclear Fuel TCD, on December 14, 2011**
- **FPL addressed the impact of TCD on the Turkey Point EPU safety analyses**

Assessment of the impact of TCD indicates acceptable results for Turkey Point EPU analyses

- **TCD impact on Turkey Point EPU analyses has minimal or no impact on most areas**
  - Fuel thermal hydraulic design
  - Core physics design
  - SBLOCA
  - Post LOCA long term cooling analysis
  - Containment pressure for MSLB
  - Radiological consequences
  - SGTR
  - Containment pressure for LBLOCA
  - Non-LOCA

FPL

Assessment of the impact of TCD indicates acceptable results for Turkey Point EPU analyses

- **Detailed assessments completed on impacted areas**
  - Fuel mechanical design
    - -- Fuel power to melt limit
    - -- Rod internal pressure
    - -- Clad strain/stress/fatigue
  - Safety Analyses
    - -- Rod Ejection
    - -- LBLOCA—Most significant area of impact
- **Analyses submitted to NRC in December 2011 and January 2012; NRC audit conducted in January 2011**
  - NRC Staff review underway

FPL

Agenda

- Introduction .... Mike Kiley
- EPU Overview and Plant Modifications.................................. Steve Hale
- Safety Analysis Overview.................. Carl O'Farrill

Acronyms

FPL

Acronyms

AFW	Auxiliary Feedwater
AST	Alternative Source Term
ATWS	Anticipated Transient without Scram
BOP	Balance of plant
CLB	Current Licensing Basis
DNB	Departure From Nucleate Boiling
DRFA	Debris Resistant Fuel Assembly
ECCS	Emergency Core Cooling System
EHC	Electro Hydraulic Control
EPU	Extended Power Uprate
F	Fahrenheit
F∆H	Hot Channel Enthalpy Rise
FQ	Heat Flux Hot Channel Factor
ft	Feet
GPM	Gallons per minute
HFP	Hot Full Power
HHSI	High Head Safety Injection
HZP	Hot Zero Power
in	Inch
Keff	K-effective
ksi	Kilo pounds per square inch
LAR	License Amendment Request
lb/hr	Pounds per hour
LEFM	Leading Edge Flow Meter
LHR	Linear Heat Rate
LOCA	Loss of Coolant Accident
MSCV	Main Steam Check Valve
MSIV	Main Steam Isolation Valve
MSLB	Main Steam Line Break
MSR	Moisture Separator Reheater
MWe	Megawatts electric
MWt	Megawatts thermal
NAMS	Nuclear Assets Management System
NPSH	Net Positive Suction Head
NSSS	Nuclear Steam Supply System
PCT	Peak Cladding Temperature
PNSC	Plant Nuclear Safety Committee
PPM	Parts per Million
Pres	Pressure
PSIA	Pound per square inch - absolute
PWR	Pressurized Water Reactor
RCS	Reactor Coolant System
RIS	Regulatory Issue Summary
RS	Review Standard
RTS	Return to Service
RWST	Refueling Water Storage Tank
SAL	Safety Analysis Limit
SDM	Shutdown Margin
Sec	Second
SG	Steam Generator
SLB	Steam Line Break
V	Velocity
ZrB_2	Zirconium Diboride
ρ	Density

FPL

UNITED STATES NUCLEAR REGULATORY COMMISSION

Protecting People and the Environment

Background of the 10 CFR 50.46c Proposed Rule and Related Activities

January 19, 2012

Tara Inverso
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Meeting Purpose

- Present the 10 CFR 50.46c proposed rule to ACRS

- Provide an overview of the related safety assessment/audit

Meeting Agenda

1. Background of 50.46c Rulemaking Activities
2. Overview of 50.46c Proposed Rule
3. Overview of BWR/PWR Owners' Group Report
4. Overview of Safety Assessment
5. Proposed Implementation Schedule

Rulemaking Purpose

- Revise ECCS acceptance criteria to reflect recent research findings
- SECY-02-0057
  - Replace prescriptive analytical requirements with performance-based requirements
  - Expand applicability to all fuel designs and cladding materials
- Address concerns raised in two PRMs: PRM-50-71 and PRM-50-84

Public Interaction

- Advance Notice of Proposed Rulemaking Published
  - August 13, 2009 (74 FR 40765)
  - Requested specific comment on 12 issues/questions
- Public Workshop
  - April 28-29, 2010
- Public Meetings on Safety Assessment
  - August 12, 2010; December 2, 2010; March 3, 2011

Recent ACRS Interaction

- Research Findings – Regulatory Basis for 50.46c Rule
  - Presented RIL-0801 and NUREG/CR-6967 on December 2, 2008 (sub-committee) and December 4, 2008 (full committee)
  - "Mechanical Behavior of Ballooned and Ruptured Cladding" presented on June 23, 2011 (sub-committee) and July 13, 2011 (full committee)
- Draft regulatory guidance:
  - Presented to ACRS on May 10, 2011 (sub-committee) and June 8, 2011 (full committee)
- Proposed Rule:
  - Presented to ACRS sub-committee on December 15, 2011

Fuel Fragmentation, Relocation, and Dispersal

- Further research is necessary to understand fuel dispersal and its significance
- The staff recommends that the 50.46c rulemaking proceed to address the known embrittlement phenomenon
  - As written, the proposed rule satisfies all objectives/Commission direction

Rulemaking Schedule

- Proposed Rule Due to the Executive Director for Operations:
  - February 29, 2012

Questions?

Tara Inverso, Project Manager

301-415-1024; tara.inverso@nrc.gov

1Q2011
2Q2011
3Q2011
4Q2011
1Q2012
2Q2012
3Q2012
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2Q2013
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1Q2019
2Q2019
3Q2019
4Q2019
1Q2020
2Q2020
3Q2020
NEI/Owners Group ECCS Margin Assessment
Done
Staff Audit & Safety Assessment
Completed: 3Q2011
10CFR50.46c Proposed Rule to EDO
Completed: 1Q2012
10CFR50.46c Proposed Rule Issued
Issued: 3Q2012
Public Comment Period
75 day comment period.
Ends: 1Q2013
Prepare Final Rule
Completed: 3Q2013
10CFR50.46c Final Rule Issued
Issued: 4Q2013
Draft RG Analytical Limits
Done
Public Comment Period
75 day comment period.
Ends: 1Q2013
Prepare RG
Completed: 3Q2013
RG Issued
Issued: 4Q2013
Draft RGs Test Procedures
Done
Round Robin
(Completed 4Q2012)
Public Comment Period
75 day comment period.
Ends: 1Q2013
Prepare RGs
Completed: 3Q2013
RGs Issued
Issued: 4Q2013
Cladding Hydrogen Uptake Models
Collect hot-cell hydrogen measurements.
Develop alloy-specific hydrogen uptake models.
Approx. 9 models
Completed: 4Q2014
LOCA Model Updates
Vendors update LOCA models and methods.
Approx. 12 models
Completed 4Q2014
Employ Reg Guide PQD Analytical Limits
Elect to Perform PQD Testing
Track #1
65 plants which require no new models nor new LOCA calculations.
Document compliance, revise UFSAR, and submit letter report to NRC.
Approx. 50 AORs.
Completion: 4Q2015
Track #2
16 PWR plants currently using realistic models and require new analysis.
2 BWR/2 plants.
Prepare LAR.
Approx. 13 AORs.
Completion: 4Q2017
NRC Review
Review Track #2 LARs.
Completed: 4Q2019
Track #3
23 PWR plants currently using Appendix K and require new analysis.
6 BWR/3 plants.
Approx. 14 AORs.
Completion: 4Q2018
NRC Review
Review Track #3 LARs.
Completed: 4Q2020
PQD Tests
Perform PQD testing.
Develop analytical limit.
Completion: 4Q2014
NRC Review
Review analytical limits.
Completed: 4Q2015
Breakaway Tests
Perform breakaway oxidation testing.
Develop analytical limits.
Completion: 4Q2014
NRC Review
Review analytical limits.
Completed: 4Q2016
NRC Review
Review vendors alloy-specific hydrogen models.
Completed: 4Q2015
NRC Review
Review LOCA models and methods.
Completed: 4Q2016
Periodic Breakaway Tests
Periodic Breakaway Tests
Periodic Breakaway Tests
Periodic Breakaway Tests
Periodic Breakaway Tests
Periodic Breakaway Tests
Periodic Breakaway Tests

Overview of the 10 CFR 50.46c Proposed Rule

January 19, 2012

Paul Clifford
Division of Safety Systems
Office of Nuclear Reactor Regulation

Agenda

- ECCS Design Function
- Structure of Performance-Based Rule
- Overview of 50.46c Rule Language

ECCS Design Function

- Emergency Core Cooling System consists of SSCs designed to replenish liquid inventory and maintain core temperatures at an acceptable level during and following a postulated LOCA.

Rule Structure

Performance-based nature necessitated major restructuring of proposed 50.46c rule.

Rule Structure (cont.)

50.46c ECCS Performance During LOCA

(a)Applicability

(b)Definitions

(c)Relationship to Other NRC Regulations

(d)ECCS Design

(e) [reserved]

(f) [reserved]

(g)Fuel System Design – (current designs)

(h) [reserved]

(i) [reserved]

(j) [reserved]

(k)Use of NRC Approved Fuel

(l)Authority to Impose Restrictions on Operation

(m)Reporting

(n) [reserved]

(o)Implementation

Rule Structure (cont.)

<u>Emergency Core Cooling System:</u>

1. Define **principal** performance objectives
   - Maintain acceptable core temperature during a LOCA.
   - Remove decay heat following a LOCA.

2. Define **principal** analytical requirements for ECCS performance demonstration

> > Dependent of Fuel Design < <

Rule Structure (cont.)

For <u>each</u> fuel design:

1. Define **specific** performance requirements and analytical limits which form the basis of "acceptable core temperature" based upon all established degradation mechanisms and unique features.

2. Define **specific** analytical requirements which impact the predicted performance of the fuel under LOCA conditions.

Rule Structure (cont.)

Current Fuel Designs:

•Based upon extensive empirical database, including recent findings from High Burnup LOCA Research Program, 50.46c defines specific performance and analytical requirements for current fuel designs.

New Fuel Designs:

•Additional research may be necessary to identify all degradation mechanisms and any unique features.

•New performance objectives, analytical limits, and analytical requirements would need to be established based upon this research.

•Several paragraphs reserved within 50.46c for future rulemaking on new fuel designs.

50.46c Rule Language

Paragraph (a)

(a) *Applicability*. The requirements of this section apply to the design of a light water nuclear power reactor (LWR), and to the following entities who design, construct or operate an LWR: each applicant for or holder of a construction permit under this part, each applicant for or holder of an operating license under this part (until the licensee has submitted the certification required under 10 CFR 50.82(a)(1) to the NRC), each applicant for or holder of a combined license under 10 CFR part 52, each applicant for a standard design certification (including the applicant for that design certification after the NRC has adopted a final design certification rule), each applicant for or holder of a standard design approval under 10 CFR part 52, and each applicant for or holder of a manufacturing license under 10 CFR part 52.

- Achieves rulemaking objective to expand applicability beyond "zircaloy or ZIRLO" to all LWRs
- Eliminates need for exemption requests for new zirconium alloys.

Paragraph (b)

(b) *Definitions*. As used in this section:

(1)Loss-of-coolant accident *(unchanged)*

(2) *Evaluation model* *(unchanged)*

(3) *Breakaway oxidation,* for zirconium-alloy cladding material, means the fuel cladding oxidation phenomenon in which weight gain rate deviates from normal kinetics. This change occurs with a rapid increase of hydrogen pickup during prolonged exposure to a high temperature steam environment, which promotes loss of cladding ductility.

- Defines new cladding embrittlement mechanism.

Paragraph (c)

(c) *Relationship to other NRC regulations.* The requirements of this section are in addition to any other requirements applicable to an emergency core cooling system (ECCS) set forth in this part. The analytical limits established in accordance with this section, with cooling performance calculated in accordance with an NRC approved evaluation model, are in implementation of the general requirements with respect to ECCS cooling performance design set forth in this part, including in particular Criterion 35 of appendix A of this part.

- Clarifies approval of evaluation model.

Paragraph (d)

(d) ***Emergency core cooling system design.***

(1) ***ECCS performance criteria.*** Each LWR must be provided with an ECCS designed to satisfy the following performance requirements in the event of, and following, a postulated loss-of-coolant accident (LOCA). The demonstration of ECCS performance must comply with paragraph (d)(2) of this section:

(i) Core temperature during and following the LOCA event does not exceed the analytical limits for the fuel design used for ensuring acceptable performance as defined in this section.

(ii) The ECCS provides sufficient coolant so that decay heat will be removed for the extended period of time required by the long-lived radioactivity remaining in the core.

- Defines ECCS performance objectives.
  - Core temperature must remain below fuel-specific analytical limits.
  - Sufficient capability for long-term cooling.

Paragraph (d) (cont.)

(2) *ECCS performance demonstration*.

ECCS performance must be demonstrated using an evaluation model meeting the requirements of either paragraph (d)(2)(i) or (d)(2)(ii), paragraph (d)(2)(iii), and paragraph (d)(2)(iv), and satisfy the analytical requirements in paragraph (d)(2)(v) of this section. The evaluation model must be reviewed and approved by the NRC.

(i) *Realistic ECCS model.* A realistic model must include sufficient supporting justification to show that the analytical technique realistically describes the behavior of the reactor system during a loss-of-coolant accident. Comparisons to applicable experimental data must be made and uncertainties in the analysis method and inputs must be identified and assessed so that the uncertainty in the calculated results can be estimated. This uncertainty must be accounted for, so that when the calculated ECCS cooling performance is compared to the applicable specified and NRC-approved analytical limits there is a high level of probability that the limits would not be exceeded.

(ii) *Appendix K model*. Alternatively, an ECCS evaluation model may be developed in conformance with the required and acceptable features of appendix K ECCS Evaluation Models.

- Requires ECCS demonstration using approved evaluation model (either App.K or realistic).

Paragraph (d) (cont.)

(iii) *Core geometry and coolant flow*. The ECCS evaluation model must address calculated changes in core geometry and must consider those factors that may alter localized coolant flow or inhibit delivery of coolant to the core.

- Requires factors which impact predicted core geometry and coolant flow be included in the evaluation model.
  - Fuel-specific factors defined in subsequent sections.

Paragraph (d) (cont.)

(iv) *LOCA analytical requirements*. ECCS performance must be demonstrated for a range of postulated loss-of-coolant accidents of different sizes, locations, and other properties, sufficient to provide assurance that the most severe postulated loss-of-coolant accidents have been identified. ECCS performance must be demonstrated for the accident, and the post-accident recovery and recirculation period.

- Clarifies demonstration during and following postulated LOCA.

Paragraph (d) (cont.)

(v) *Modeling requirements for fuel designs-uranium oxide or mixed uranium-plutonium oxide pellets within zirconium-alloy cladding*. If the reactor is fueled with uranium oxide or mixed uranium-plutonium oxide pellets within cylindrical zirconium-alloy cladding, then the ECCS evaluation model must address the fuel system modeling requirements in paragraph (g)(2) of this section.

•Pointer to analytical requirements for current fuel designs.

Paragraph (d) (cont.)

(3) *Required documentation.*

(i)(A) (unchanged from Appendix K)

(B). (unchanged from Appendix K)

(ii). (unchanged from Appendix K)

(iii). (unchanged from Appendix K)

(iv). (unchanged from Appendix K)

(v). (unchanged from Appendix K)

(vi) For operating licenses issued under this part as of **[EFFECTIVE DATE OF RULE]**, required documentation of Table 1 must be submitted to demonstrate compliance by the date specified in Table 1.

- Specifies documentation requirements for Appendix K and realistic models.
- Pointer to implementation schedule.

Paragraph (g)

(g) *Fuel system designs: uranium oxide or mixed uranium-plutonium oxide pellets within cylindrical zirconium-alloy cladding.*

(1) *Fuel performance criteria.* Fuel consisting of uranium oxide or mixed uranium-plutonium oxide pellets within cylindrical zirconium-alloy cladding must be designed to meet the following requirements:

(i) *Peak cladding temperature*. Except as provided in paragraph (g)(1)(ii) of this section, the calculated maximum fuel element cladding temperature shall not exceed 2200º F.

- Specifies performance requirements and analytical limits used to judge ECCS performance for current fuel designs.
- Research confirmed embrittlement above 2200 ºF.
- PCT limit also prevents runaway oxidation and high temperature failure.

Paragraph (g) (cont.)

(ii) *Cladding embrittlement*. Analytical limits on peak cladding temperature and integral time at temperature shall be established which correspond to the measured ductile-to-brittle transition for the zirconium-alloy cladding material based on a NRC-approved experimental technique. The calculated maximum fuel element temperature and time at elevated temperature shall not exceed the established analytical limits. The analytical limits must be approved by the NRC. If the peak cladding temperature, in conjunction with the integral time at temperature analytical limit, established to preserve cladding ductility is lower than the 2200º F limit specified in (g)(1)(i), then the lower temperature shall be used in place of the 2200º F limit.

- Maintains cladding ductility as performance objective.
- Captures research finding.
  - Hydrogen enhanced beta-layer embrittlement.
- RG provides acceptable analytical limits.
- RG provides acceptable experimental technique.

Paragraph (g) (cont.)

(iii) *Breakaway oxidation.* The total accumulated time that the cladding is predicted to remain above a temperature at which the zirconium-alloy has been shown to be susceptible to breakaway oxidation shall not be greater than a limit which corresponds to the measured onset of breakaway oxidation for the zirconium-alloy cladding material based on a NRC-approved experimental technique. The limit must be approved by the NRC.

- Maintains cladding ductility as performance objective.
- Captures research finding.
  – Breakaway oxidation (hydrogen uptake)
- RG provides acceptable experimental technique.

Paragraph (g) (cont.)

(iv) *Maximum hydrogen generation*. The calculated total amount of hydrogen generated from any chemical reaction of the fuel cladding with water or steam shall not exceed 0.01 times the hypothetical amount that would be generated if all of the metal in the cladding cylinders surrounding the fuel, excluding the cladding surrounding the plenum volume, were to react.

- Maintains existing requirement for combustible gas.

Paragraph (g) (cont.)

(v) *Long-term cooling*. An analytical limit on long-term peak cladding temperature shall be established which corresponds to the measured ductile-to-brittle transition for the zirconium-alloy cladding material based on a NRC-approved experimental technique. The calculated maximum fuel element temperature shall not exceed the established analytical limit. The analytical limit must be approved by the NRC.

- Maintains cladding ductility as performance objective.

Paragraph (g) (cont.)

(2) ***Fuel system modeling requirements.*** The evaluation model required by paragraph (d)(2) of this section must model the fuel system in accordance with the following requirement:

(i) If an oxygen source is present on the inside surfaces of the cladding at the onset of the LOCA, then the effects of oxygen diffusion from the cladding inside surfaces must be considered in the evaluation model.

- Specifies analytical requirements for current fuel designs.
- Captures research finding.
  - Oxygen ingress from cladding inside surface reduced time-at-temperature to nil ductility.

Paragraph (g) (cont.)

(ii) The thermal effects of crud and oxide layers that accumulate on the fuel cladding during plant operation must be evaluated. For purposes of this paragraph crud means any foreign substance deposited on the surface of fuel cladding prior to initiation of a LOCA.

- Achieves rulemaking objective to address petition for rulemaking.

Paragraph (k)

(k) *Use of NRC-approved fuel in reactor*. A licensee may not load fuel into a reactor, or operate the reactor, unless the licensee either determines that the fuel meets the requirements of paragraph (d) of this section, or complies with technical specifications governing lead test assemblies in its license.

- Clarifies requirement on use of NRC approved fuel designs for which specific ECCS performance requirements have been established.
- Recognizes importance of LTAs for collecting irradiated data to approve new fuel designs.

Paragraph (l)

(l) ***Authority to impose restrictions on operation.*** The Director of the Office of Nuclear Reactor Regulation (for licenses issued under 10 CFR part 50) or the Director of the Office of New Reactors (for licenses issued under 10 CFR part 52) may impose restrictions on reactor operation if it is found that the evaluations of ECCS cooling performance submitted are not consistent with the requirements of this section.

- Separates authority between NRR and NRO for imposing restrictions on operation.

Paragraph (m)

(m) *Reporting*.

(1) Each entity subject to the requirements of this section, which identifies any change to or error in an evaluation model or the application of such a model, or any operation inconsistent with the evaluation model or resulting noncompliance with the acceptance criteria in this section, shall comply with the requirements of this paragraph.

- Clarifies existing reporting requirements.

Paragraph (m) (cont.)

(2) For the purposes of this section, a significant change or error is one which results in a calculated –

(i) Peak fuel cladding temperature different by more than 50 ^{0}F from the temperature calculated for the limiting transient using the last NRC-approved model, or is a cumulation of changes and errors such that the sum of the absolute magnitudes of the respective temperature changes is greater than 50 ^{0}F; or

(ii) Integral time at temperature different by more than 0.4 percent ECR from the oxidation calculated for the limiting transient using the last NRC-approved model, or is a cumulation of changes and errors such that the sum of the absolute magnitudes of the respective oxidation changes is greater than 0.4 percent ECR.

- Maintains threshold for significant change in calculated PCT at 50^{o}F.
- Adds a new threshold for significant change in calculated integral time at temperature of 0.4% ECR.

Paragraph (m) (cont.)

(3) Each holder of an operating license or combined license shall measure breakaway oxidation for each reload batch. The holder must report the results to the NRC annually i.e., anytime within each calendar year, in accordance with § 50.4 or § 52.3 of this chapter, and evaluate the results to determine if there is a failure to conform or a defect that must be reported in accordance with the requirements of 10 CFR part 21.

- Adds new reporting requirement for measured breakaway oxidation.
- Recognizes potential manufacturing-related changes in breakaway susceptibility.

Paragraph (o)

(o) ***Implementation.***

LATER

U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

Implementation of 10 CFR 50.46c

January 19, 2012

Paul Clifford
Division of Safety Systems
Office of Nuclear Reactor Regulation

Agenda

1. Work Scope

2. Strategy

3. Implementation – Existing Plants

4. Implementation – New Plants

Work Scope

Industry:

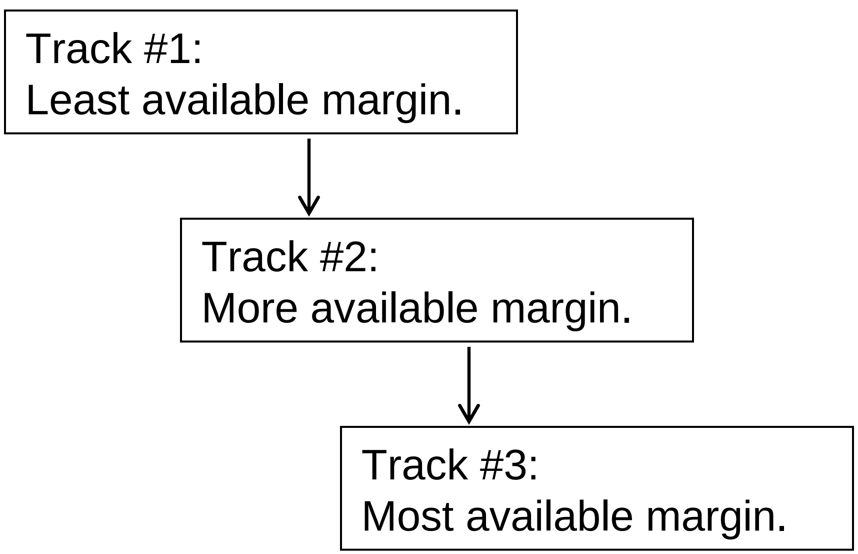
1. Develop alloy-specific hydrogen uptake models.
2. Update LOCA models.
3. Establish PQD analytical limits.
4. Establish breakaway oxidation analytical limits.
5. Perform plant-specific LOCA analyses.
6. Prepare LARs.
7. Revise UFSARs.
8. Ongoing breakaway tests.

NRC:

1. Review alloy-specific hydrogen uptake models.
2. Review LOCA models.
3. Review breakaway test results
4. Review PQD and breakaway analytical limits.
5. Review LARs.

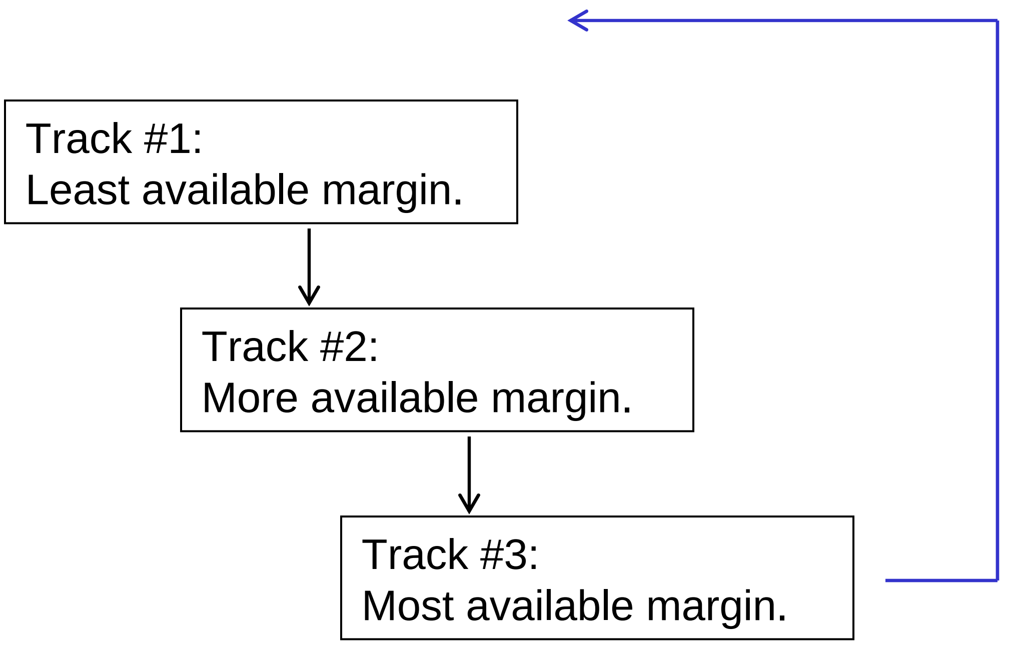
Strategy

- Based upon ANPR comments which identified work-force limitations to complete parallel analyses, a staged implementation plan would be the most effective and efficient way to implement 50.46c.
- Plants with the least available safety margin would be required to be in compliance earliest.



Strategy (cont.)

- Recognizing that (1) plants with the least amount of safety margin are likely to require the most effort and calendar time to document compliance and (2) a substantial number of plants do not require new LOCA analyses, the implementation plan revised.



Strategy (cont.)

- Implementation plan designed to achieve the following objectives:
  1. Expedite implementation to as many plants as soon as possible,
  2. Prioritize implementation on plants with less inherent safety margin, and
  3. Balance work load.

Implementation – Existing Fleet

Implementation Track	Basis	Anticipated Level of Effort	Number of Plants		Compliance Demonstration
			BWR	PWR	
1	All plants which satisfy new requirements without new analyses or model revisions.	Low	27	38	No later than 24 months from effective date of rule
2	PWR plants using realistic LBLOCA models requiring new analyses. BWR/2 plants.	Medium	2	14	No later than 48 months from effective date of rule
3	PWR plants using Appendix K LB and SB models requiring new analyses. BWR/3 plants.	Medium - High	6	17	No later than 60 months from effective date of rule

Paragraph (o)

(o) ***Implementation***

<u>Reactors under Part 50:</u>

•Construction permits issued after the effective date of the rule must comply with the conditions of the rule.

•Operating licenses issued based on construction permits in effect as of the effective date of the rule must comply with the conditions of the rule no later than the date set forth in Table 1 of the rule.

•Operating licenses issued prior to the effective date of the rule must comply with the conditions of the rule no later than the date set forth in Table 1 of the rule.

•Operating licenses issued after the effective date of the rule must comply with the conditions of the rule.

Paragraph (o)

(o) *Implementation.*

<u>Reactors under Part 52:</u>

•All applications docketed after the effective date of the rule must comply with the conditions of the rule prior to approval.

•Standard design renewals after the effective date of the rule must comply with the conditions of the rule prior to approval.

•Standard design applications pending at effective date of the rule must comply with the conditions of the rule when renewal is submitted.

•Combined licenses docketed after the effective date of the rule must comply with the conditions of the rule.

•Combined licenses docketed or issued prior to the effective date of the rule must comply with the conditions of 50.46 until completion of the refueling outage after the initial fuel load, at which time they must comply with the conditions of this rule.

Implementation Flow Chart

ECCS Performance Safety Assessment

January 19, 2012

Paul Clifford
Division of Safety Systems
Office of Nuclear Reactor Regulation

Agenda

1. Research Findings

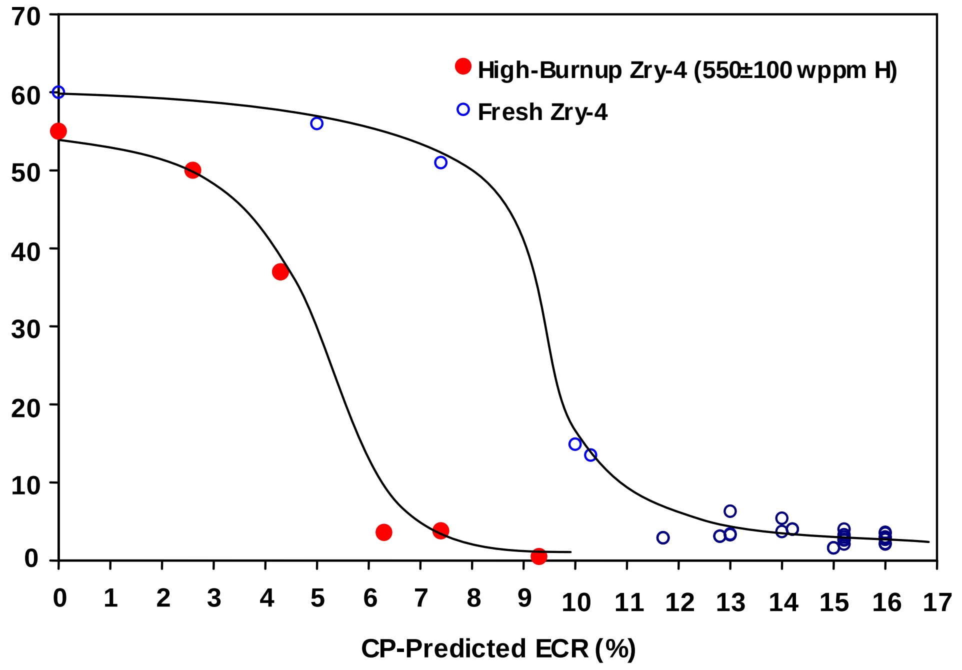
2. Initial Safety Assessment

3. ECCS Performance Assessment

Research Findings

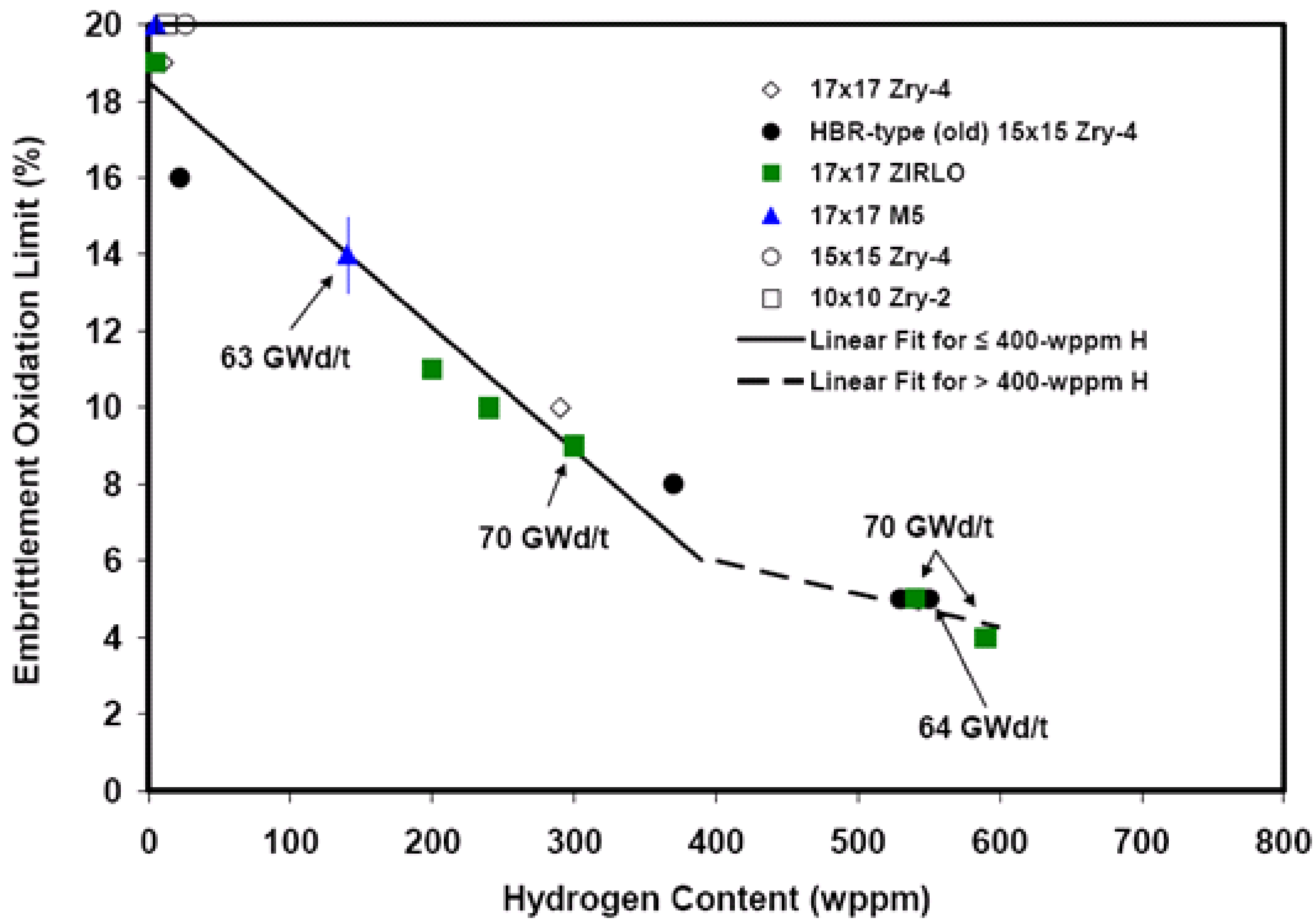
New Embrittlement Mechanisms:

1. Hydrogen-enhanced beta layer embrittlement.
   - Pre-transient cladding hydrogen content impacts rate of embrittlement.
   - Hydrogen absorption sensitive to alloy composition, fabrication, and in-reactor service.



Research Findings (cont.)

- Allowable time-at-temperature reduced from current regulatory requirement (17%ECR).

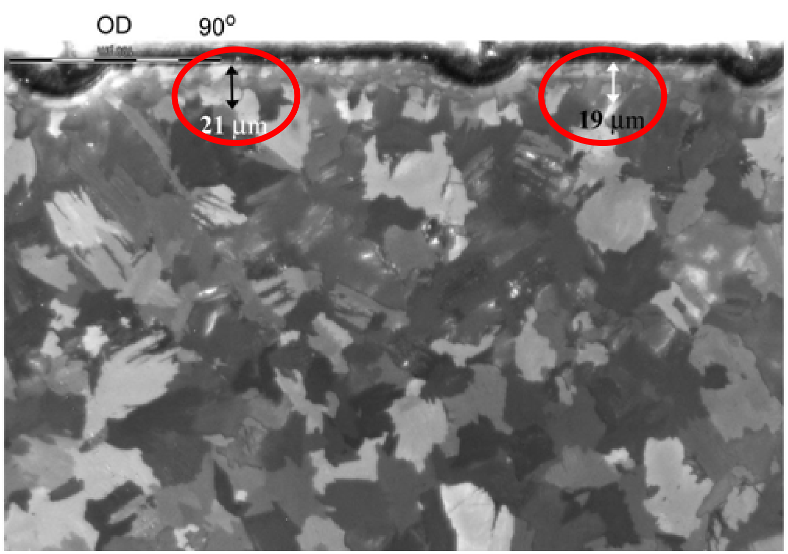


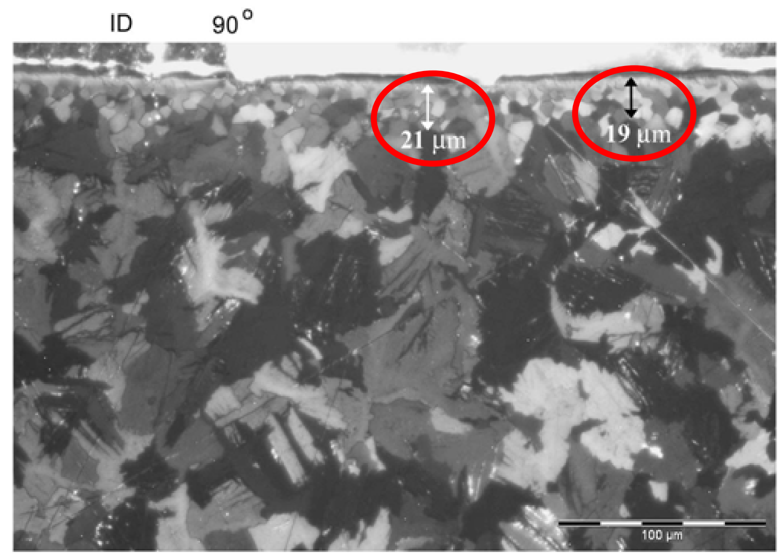
Research Findings (cont.)

New Embrittlement Mechanisms:

2. Cladding ID oxygen diffusion expedites embrittlement.

- Oxygen ingress from cladding ID reduces allowable time-at-temperature to nil ductility.
- ID oxygen source sensitive to burnup, power history, and fuel rod design.



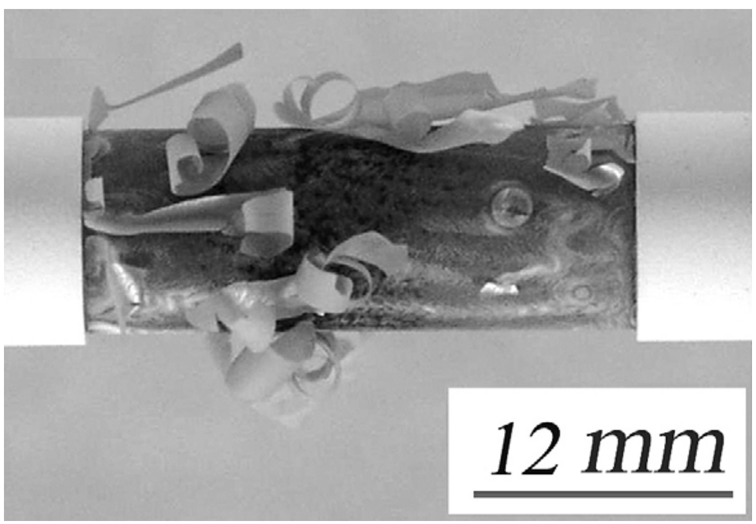


Micrograph images of Halden LOCA test specimens of outer cladding surface (left) and inner cladding surface (right) indicating oxygen-stabilized zirconium layers on both surfaces.

Research Findings (cont.)

New Embrittlement Mechanisms

3. Degradation of protective oxide layer (breakaway oxidation).
   - Breakaway oxidation results in cladding embrittlement due to hydrogen uptake.
   - Susceptibility to breakaway sensitive to alloy composition and fabrication.



Alloy	Measured Breakaway Time
Zircaloy-2	>5,000 seconds
Zircaloy-4	5,000 seconds
ZIRLO™	3,500 seconds
M5	>5,000 seconds

Reaction to Research Findings

Response to new research data depends on the answers to the following questions:

1. Are the research findings credible?
2. Is the research complete?
3. Are current regulations adequate?
4. Is there an imminent risk to public health and safety?

Initial Safety Assessment

In response to RIL-0801, NRR completed initial safety assessment (July 2008)

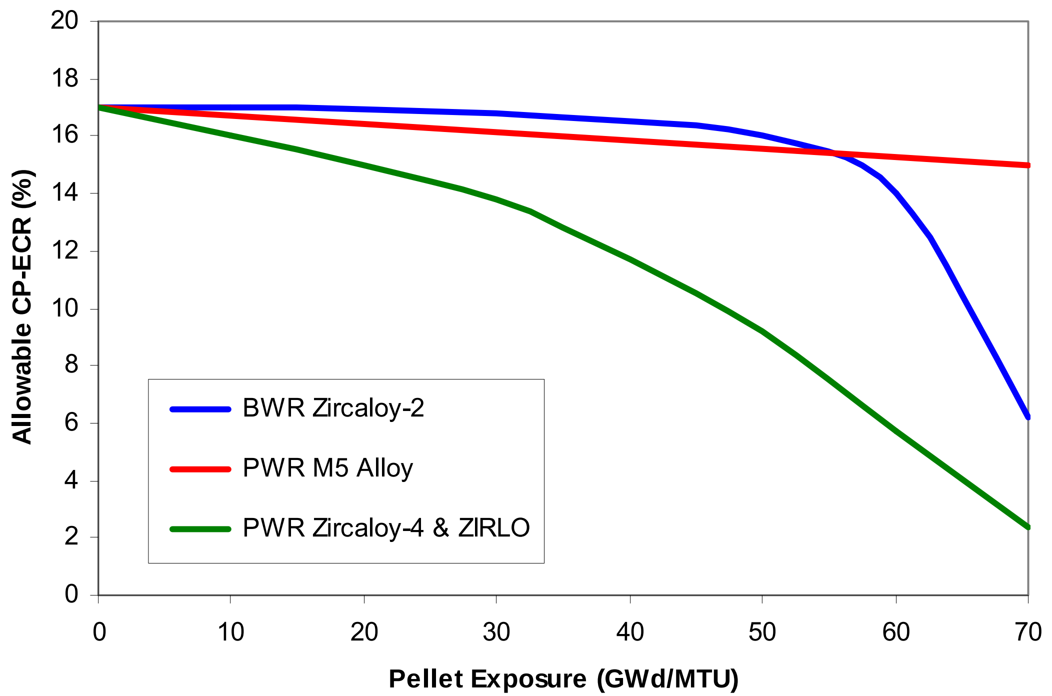
- Due to measured performance, realistic rod power history, and current analytical conservatisms, sufficient safety margin exists for operating reactors.
- No imminent safety risk.
- Proceed with rulemaking.
- Additional research needs:
  - PQD measurements at intermediate hydrogen levels.
  - Breakaway measurements on transient temperature profiles.
  - Treatment of fuel rod burst region.

ECCS Performance Assessment

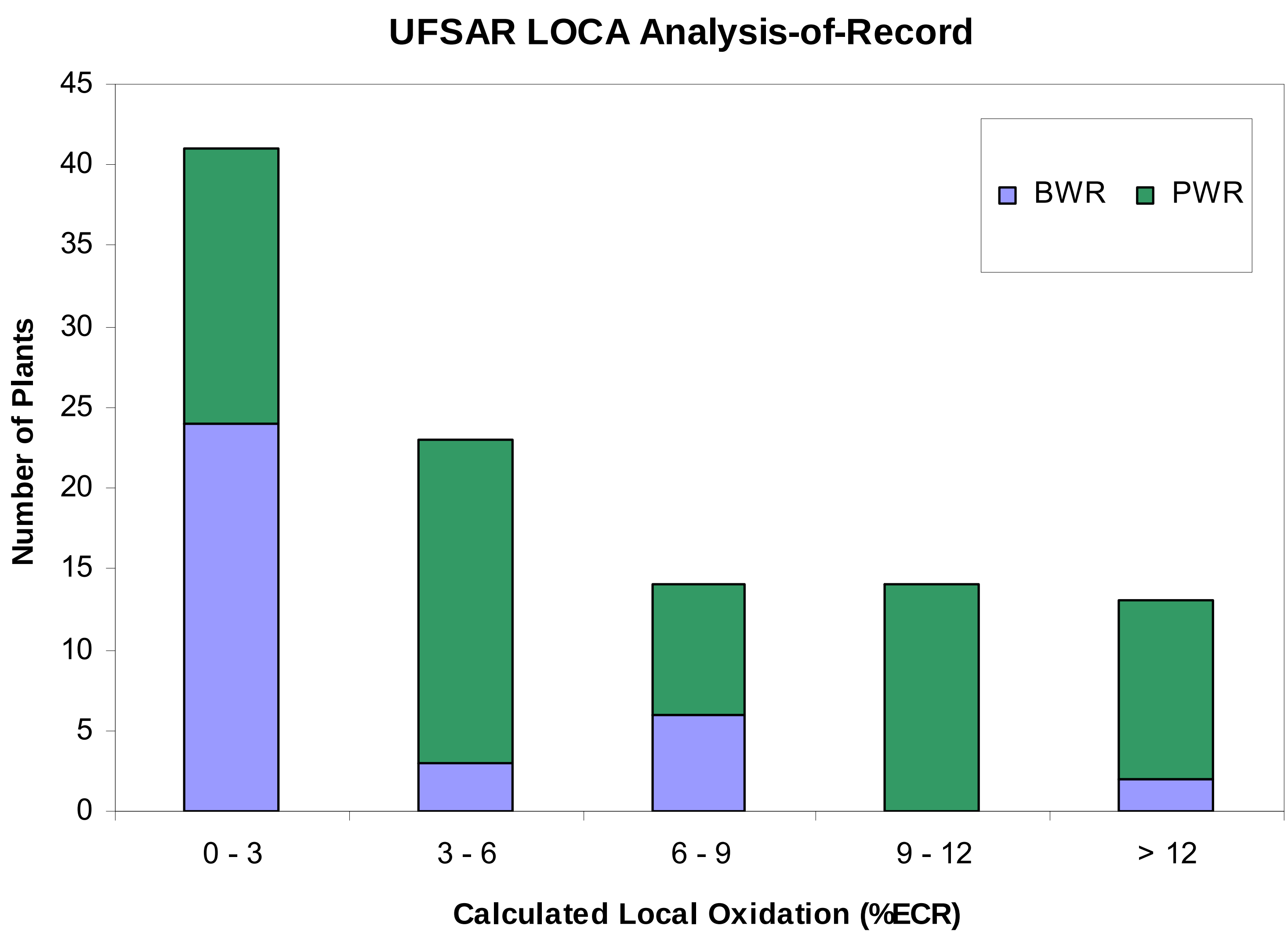
Groundrules

Revised Analytical Limits:

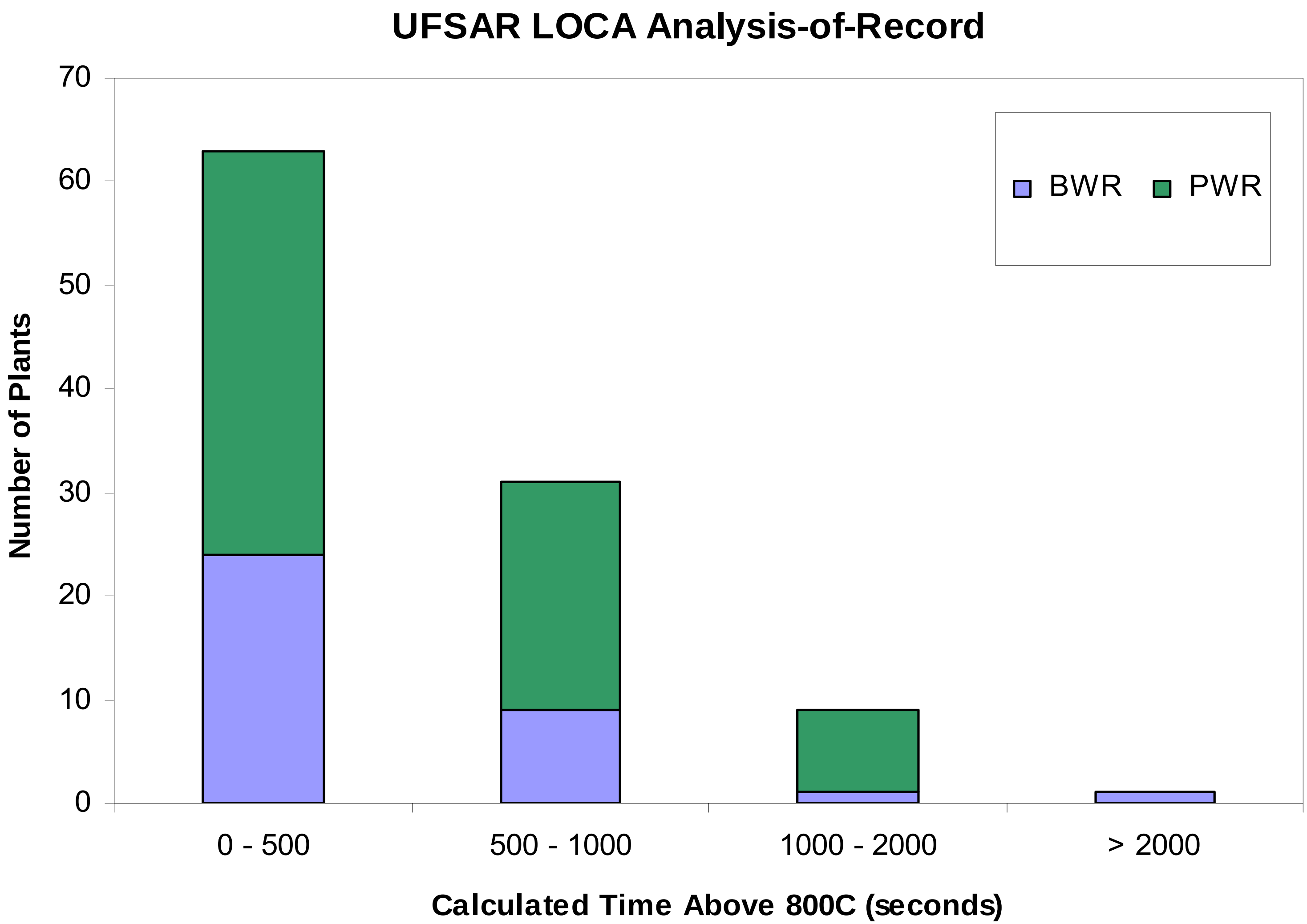
- Alloy-specific PQD analytical limit.
- Cladding ID oxygen ingress $\geq$ 45 GWd/MTU.
- Alloy-specific breakaway oxidation (time above 800°C).



UFSAR AOR Results - MLO



UFSAR AOR Results – Breakaway



Post Quench Ductility

Revised PQD Analytical Limits:

- 65 of 104 plants (63% of entire operating fleet) needed no adjustment or new calculations.
  - 27 of 35 BWRs (77% of BWR fleet)
  - 38 of 69 PWRs (55% of PWR fleet).

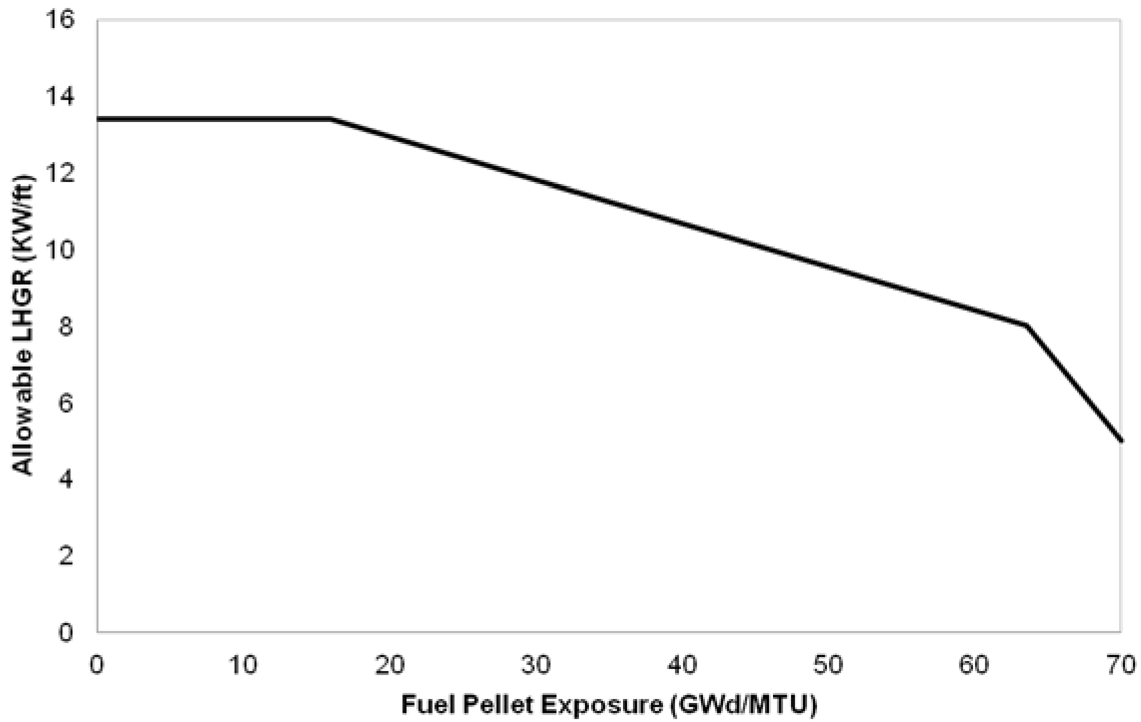
- All 104 plants continue to satisfy 2200^{o}F PCT criteria.

Post Quench Ductility (cont.)

Revised PQD Analytical Limits:

•8 BWRs performed new LOCA calculations which credit COLR Thermal-Mechanical Operating Limits (TMOL) reduced rod power at higher burnup to satisfy new analytical limits.

•Approved models with no analytical adjustments.



Post Quench Ductility (cont.)

Revised PQD Analytical Limits:

- 31 PWRs either performed new LOCA calculations or identified credits to satisfy new analytical limits.
  - 9 PWRs performed new LOCA calculations which credit diminished fuel rod power at higher burnup.
  - 11 PWRs credit transition to improved evaluation models (e.g., ASTRUM LBLOCA or ANS 1979+2σ decay heat SBLOCA).
  - 4 PWRs credit improved statistics in ASTRUM methods.
  - 7 PWRs credited multiple items.

- All of the calculations were performed and documented in accordance with the fuel vendor's 10 CFR 50 Appendix B quality assurance program.

Breakaway Oxidation

Measured Breakaway Time:

•All plants exhibit margin to breakaway.

•103 of 104 plants predict a time duration above 800^{o}C of less than 2,000 seconds.

Staff Audit

NRC staff audited Westinghouse, AREVA, and GEH calculations supporting OG reports.

- Confirmed that the revised PQD and breakaway analytical limits were in accordance with the research findings and that alloy-specific corrosion and hydrogen uptake models were accurate and supported by data.
- Evaluated the quantification, justification, and application of analytical credits.
- Reviewed a sampling of the new LOCA calculations and identified any changes to existing, approved models and methods.
- Compiled plant-specific data and evaluated each individual plant with respect to margin to the revised analytical limits.

ECCS Margin Database

ECCS Margin Database documents plant-specific information:

- Fuel vendor
- Fuel rod cladding alloy
- Evaluation model
- AOR results (calculated PCT, MLO, and time above 800°C)
- Plant grouping
- Margin to PQD analytical limit
- Margin to breakaway oxidation analytical limit
- Credited analytical adjustment(s)

Existing Commercial Fleet

- ECCS performance safety assessment confirms and documents, on a plant-specific basis, the continued safe operation of the U.S. commercial nuclear fleet.

- Future operation of Watts Bar Unit 2 and Bellefonte Units 1 and 2 expected to have sufficient margin to PQD and breakaway limits.

- Improved, corrosion resistant zirconium alloys being developed and implemented.

Certified Reactor Designs

- Advanced reactor designs include enhanced ECCS performance characteristics.

- Certified designs have significant margin relative to research data.

Design	PCT (ºF)	ECR (%)
ESBWR	No uncovery or heatup	
AP1000	1837	2.25
EPR	1695	1.53
US-APWR	1766	3.70

Conclusions

1. Research findings necessitate new ECCS requirements.
2. Majority of plants needed no new calculations or adjustments to show positive margin to the research data.
3. ECCS margin database confirms and documents, on a plant-specific basis, the continued safe operation of the U.S. commercial nuclear fleet.
4. NRC staff will continue to confirm plant safety until new regulations have been implemented.

Industry Comments on Proposed 10cfr50.46(c)

Gordon Clefton
NEI

January 19, 2012

NUCLEAR ENERGY INSTITUTE

Discussion Issues

- Comment period length
- Implementation plan
- On-going reporting

Comment Period Length

- No safety concern; no rush needed
- Estimated ten year implementation
- Comments requested on:
  - 10cfr50.46(c) Rule
  - Three Regulatory Guides

DATES: Submit comments on the rule and draft guidance by [INSERT DATE 75 DAYS AFTER PUBLICATION IN THE FEDERAL REGISTER]. To facilitate NRC review, please distinguish between comments submitted on the proposed rule and comments submitted on the draft guidance. Submit comments on the information collection aspects of this rule by [INSERT DATE 30 DAYS AFTER PUBLICATION IN THE FEDERAL REGISTER].

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Implementation Plan

- Three Implementation Tracks in Table 1:
  - 1 No later than 24 months (65 plants; 38-PWR & 27-BWR)
  - 2 No later than 48 months (15 plants; 14-PWR & 1-BWR)
  - 3 No later than 60 months (23 plants; 17-PWR & 6-BWR)
    - Note: Oyster Creek (BWR) not listed

- (4) Operating licenses issued under this part as of [EFFECTIVE DATE OF RULE] must comply with the requirements this section by no later than the applicable date set forth in Table 1. Until such compliance is achieved, the requirements of § 50.46 continue to apply.

On-going Reporting

- Adds new reporting requirement for measured breakaway oxidation
- Proposed Rule
  - (3) Each holder of an operating license or combined license shall measure breakaway oxidation for each reload batch. The holder must report the results to the NRC annually i.e., anytime within each calendar year, in accordance with § 50.4 or § 52.3 of this chapter, and evaluate the results to determine if there is a failure to conform or a defect that must be reported in accordance with the requirements of 10 CFR part 21.

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Industry Comments on Proposed 10cfr50.46(c)

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January 19, 2012

Overview of Industry Margin Assessment Reports

Gordon Clefton
NEI
January 19, 2012

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Report Objective

- Show operating plants have margin with respect to research findings
  - Hydrogen concentration in cladding material plays a role in post quench ductility
  - Results suggest a change in the local oxidation acceptance criteria

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Margin Assessment Process

– Fuel Suppliers/Plants surveyed existing

– Identified evaluation criteria

– Identified conservatisms and margins

– Grouped Plants for reporting results

Applied Conservatism Examples

- Appendix K vs. Best-Estimate Methodology
- Approved Best-Estimate Methodology Improvements
- Baker-Just vs. Cathcart-Pawel
- Reload Power History
- Peak Cladding Temperature Dependent Brittle-Ductile Transition
- ANS-1979 Decay Heat Plus 2σ Uncertainty
- Thermal-Mechanical Limits to Operation
  - LHGR limit

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Plant Grouping Factors

– Large vs. Small Break Limited

– Plant Design/ECCS Features

– Type of Cladding Material

– Type of Evaluation Methodology

– Conservatism Credits

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Margin to Proposed Criteria

- Embrittlement
  - Needed no adjustments
    - 41 of 69 PWR LBLOCA
    - 59 of 69 PWR SBLOCA
    - 27 of 35 BWRs
  - Remaining plants took credit for various conservatisms
- Breakaway Oxidation
  - No adjustments needed

Conclusion

- All operating Plants show margin with respect to new research findings concerning hydrogen concentration in cladding material

- The current operating fleet can meet the proposed change in the local oxidation acceptance criteria

Overview of Industry Margin Assessment Reports

Gordon Clefton
NEI
January 19, 2012

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